INDUSTRIAL
MECHANICS
WORKBOOK

R. T. Miller

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Introduction

Industrial Mechanics Workbook provides tests based on the content of *Industrial Mechanics*. The tests in *Industrial Mechanics Workbook* correlate with each chapter in *Industrial Mechanics*. The corresponding chapter of *Industrial Mechanics* should be studied before taking the tests. Particular attention should be paid to formulas, illustrations, and italicized terms. A comprehensive Final Exam follows the chapter tests. The Appendix contains all formulas, charts, and tables required to solve all problems in the chapter tests.

Test questions include identification, matching, completion, multiple choice, true-false, and problems. All answers, with solutions as appropriate, are given in *Industrial Mechanics Workbook Instructor's Guide*.

We appreciate the use of technical material and illustrations as noted in this workbook.

The Publisher

made in
USA

Contents

Calculations

Chapter 1
Test 1

Name _____   Date _____

Industrial Mechanics

equation   1. A(n) _____ is a means of showing that two numbers or two groups of numbers are equal to the same amount.

Plane   2. A(n) _____ figure is a flat figure with no depth.

Angle   3. A(n) _____ is the intersection of two lines or sides.

T̃   F   4. All circles contain 360°.

T   F   5. The sum of the three angles of a triangle is always 90°.

C   6. A quadrilateral always _____.

     A. has four sides   C. both A and B
     B. contains 360°   D. neither A nor B

altitude   7. The _____ of a prism is the perpendicular distance between the two bases.

T̃   F   8. A right cylinder is a cylinder with the axis perpendicular to the base.

Sphere   9. A(n) _____ is a solid generated by a circle revolving about one of its axes.

formula   10. A(n) _____ is a mathematical equation that contains a fact, rule, or principle.

Area   11. _____ is the number of unit squares equal to the surface of an object.

base   12. The _____ of a triangle is the side upon which the triangle stands.

Square   13. A(n) _____ is a quadrilateral with all sides equal and four 90° angles.

rectangle   14. A _____ is a quadrilateral with opposite sides equal and four 90° angles.

     A. square   C. rhombus
     B. rectangle   D. rhomboid

Rhombus   15. A _____ is a quadrilateral with all sides equal and no 90° angles.

     A. square   C. rhombus
     B. rectangle   D. rhomboid

Rhomboid   16. A(n) _____ is a quadrilateral with opposite sides equal and no 90° angles.

T̃   F   17. A formula can be changed to solve for any unknown value if the other values are known.

T   **F̃**   18. A square foot contains 12 sq in.

T̃   F   19. Polyhedra are solids bound by plane surfaces.

_____B_____ **20.** A(n) _____ is a regular solid of eight triangles.

    A. hexahedron   C. tetrahedron
    B. octahedron   D. dodecahedron

_____D_____ **21.** A(n) _____ is a regular solid of twelve pentagons.

    A. hexahedron   C. tetrahedron
    B. octahedron   D. dodecahedron

_____A_____ **22.** A(n) _____ is a regular solid of six squares.

    A. hexahedron   C. tetrahedron
    B. octahedron   D. dodecahedron

tetrahedron **23.** A(n) _____ is a regular solid of four triangles.

___1000___ **24.** The prefix kilo (k) has a prefix equivalent of _____.

Frustum **25.** A(n) _____ of a pyramid or cone is the remaining portion of a pyramid or cone with a cutting plane passed parallel to the base.

Lines

_____A_____ **1.** Line   **A.** Shortest distance between two points

_____F_____ **2.** Straight line   **B.** Line that is slanted

_____E_____ **3.** Horizontal line   **C.** Two or more lines that remain the same distance apart

_____D_____ **4.** Vertical line   **D.** Line that is perpendicular to the horizon

_____B_____ **5.** Inclined line   **E.** Line that is parallel to the horizon

_____C_____ **6.** Parallel lines   **F.** Boundary of a surface

Angles

_____E_____ **1.** Complementary

_____F_____ **2.** Supplementary

_____B_____ **3.** Right

_____A_____ **4.** Straight

_____C_____ **5.** Acute

_____D_____ **6.** Obtuse
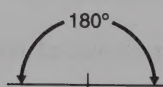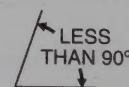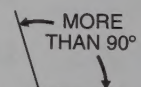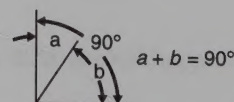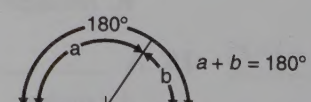
Circles

_____J_____ **1.** Centerpoint

_____H_____ 2. Angle

_____C_____ 3. Chord

_____A_____ 4. Sector

_____G_____ **5.** Diameter

_____F_____ 6. Semicircle

_____E_____ 7. Segment

_____B_____ **8.** Radius

_____D_____ 9. Quadrant

_____I_____ 10. Arc
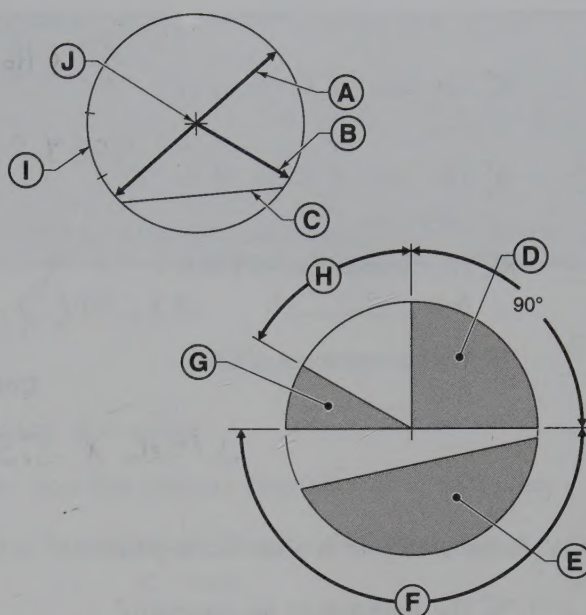
Polygons

_____B_____ **1.** Quadrilateral

_____D_____ **2.** Hexagon

_____E_____ **3.** Heptagon

_____C_____ **4.** Pentagon

_____F_____ **5.** Octagon

_____A_____ **6.** Triangle
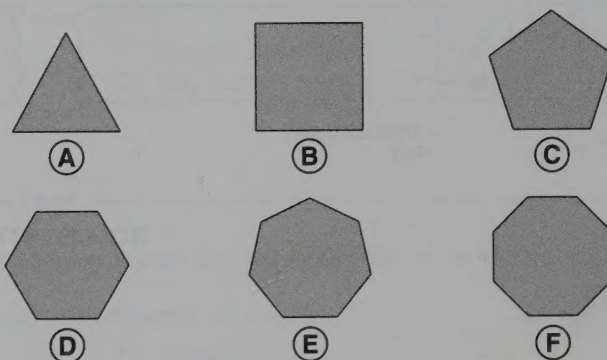
Triangles

_____B_____ **1.** Isosceles

_____C_____ **2.** Equilateral

_____A_____ **3.** Right

_____D_____ **4.** Scalene (acute)

_____E_____ **5.** Scalene (obtuse)

4 INDUSTRIAL MECHANICS WORKBOOK
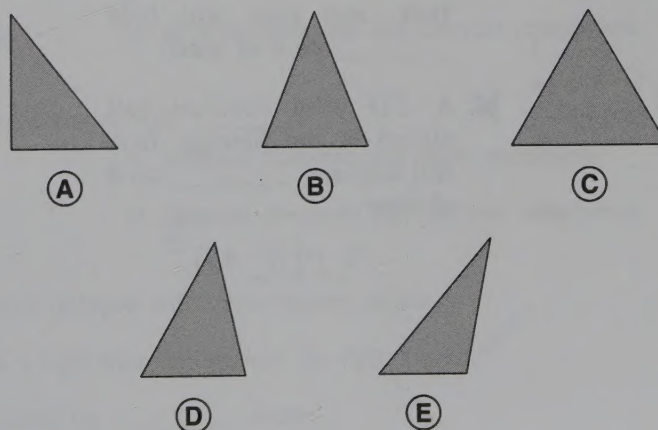
Problems

__380.13__ ~~1.~~ The area of Circle A is _____ sq in.

$.3141 6 \times 11^2 =$

__9.62__ ~~2.~~ The area of Circle B is _____ sq in.

$.7854 \times 3.5^2 =$

__69.12__ ~~3.~~ The circumference of Circle A is _____ ".

$2 \times 3.1416 \times 11$

__11.00__ ~~4.~~ The circumference of Circle B is _____ '.

3.1416×3.5
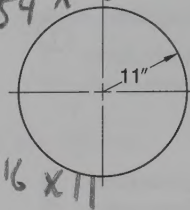
CIRCLE A (11")
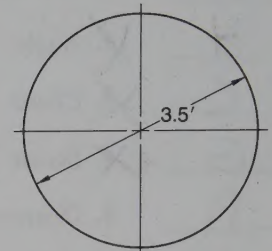
CIRCLE B (3.5')

The piece of ⅛" Rolled Steel is to be shear cut to produce 6" × 8" × 10" triangular fins.

__5.33__ sq ~~5.~~ The Rolled Steel has an area of _____ sq ft.

$96'' \times 8'' = 768 \div .144 = $ 59

__24"__ sq ~~6.~~ The area of each triangular fin is _____ sq in.

$\frac{1}{2} \frac{6}{1} \frac{8}{1}$

__32__ ~~7.~~ A total of _____ triangular fins can be produced from the Rolled Steel.

6" — TRIANGULAR FIN — 8'-0"

ROLLED STEEL — 8"
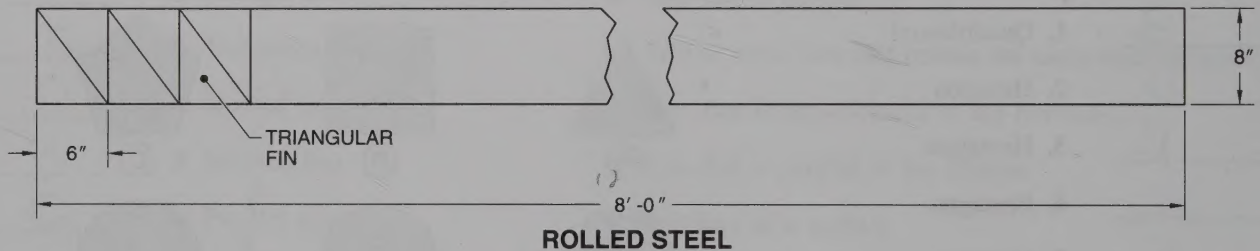
__157.08__ cu' ~~8.~~ The Storage Tank will hold _____ cu ft of water.

$.7854 \times 5^2 \times 8'$

__183.79__ cu ~~9.~~ The Holding Tank, Storage Tank, and pipe will hold _____ cu ft of water.

__25.13__ cu ~~10.~~ A 2'D solid concrete ball placed in the Storage Tank will displace _____ cu ft of water.

$3.1416 \cdot 2^3$

5'-0"D

6"D x 3'-0" PIPE

2.5'D

4'-0"

8'-0"

19.64

HOLDING TANK   7.07'   **STORAGE TANK**
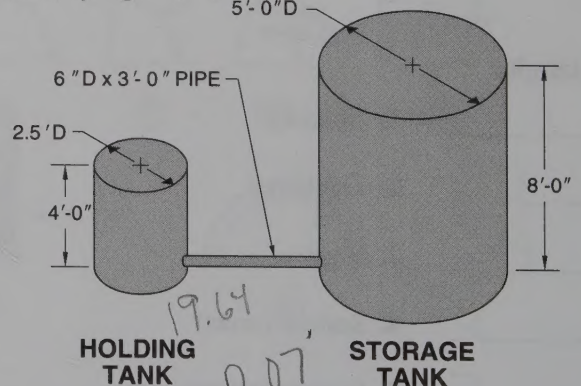
183.79

Calculations

Chapter 1
Test 2

Name _____   Date _____

Industrial Mechanics

Line **1.** A(n) _____ is the boundary of a surface.

Right **2.** A(n) _____ angle is two lines that intersect perpendicular to each other.

vertex **3.** The _____ is the point of intersection of the sides of an angle.
   A. centerpoint   C. vertex
   B. radius   D. neither A, B, nor C

horizontal **4.** A(n) _____ line is a line that is perpendicular to the horizon.
   A. horizontal   C. inclined
   B. vertical   D. neither A, B, nor C

A **5.** An acute angle is an angle that _____.
   A. contains less than 90°   C. contains more than 90°
   B. contains exactly 90°   D. may contain any number of degrees

(T)   F   **6.** There are 60′ in one degree.

T   (F)   **7.** A straight angle always contains 90°.

(T)   F   **8.** All lines may be drawn in any position unless they are horizontal or vertical.

B **9.** A _____ is a portion of the circumference of a circle.
   A. vector   C. segment
   B. chord   D. neither A, B, nor C

C **10.** Concentric circles are two or more circles with _____.
   A. same diameters and   ✓ C. different diameters and same centerpoint
      same centerpoints
   B. same diameters and   D. different diameters and different centerpoints
      different centerpoints

D **11.** Eccentric circles are two or more circles with _____.
   A. same diameters and   C. different diameters and same centerpoint
      same centerpoints
   B. same diameters and   D. different diameters and different centerpoints
      different centerpoints

Triangle **12.** A(n) _____ is a three-sided polygon with three interior angles.

Hypotenuse **13.** The _____ is the side of a right triangle opposite the right angle.

uppercase **14.** The angles of a triangle are named by _____ letters.

5

Lowercase **15.** The sides of a triangle are named by _____ letters.

(T)   F   **16.** Polygons are named according to their number of sides.

(T)   F   **17.** A right triangle has a 3-4-5 relationship.

Prisms   **18.** A(n) _____ is a solid with two bases that are parallel and identical polygons.

Pyramid   **19.** A(n) _____ is a solid with a base that is a polygon and sides that are triangles.

Volume   **20.** _____ is the three-dimensional size of an object measured in cubic units.

_____D_____ **21.** A cubic inch measures _____ or its equivalent.

A. 1″   C. 1″ × 1″
B. 1″ sq   D. neither A, B, nor C

_____C_____ **22.** An obtuse triangle is a scalene triangle with _____.

A. one angle less than 90°   C. one angle greater than 90°
B. one angle of 90°   D. two angles of 90°

_____C_____ **23.** A polygon is _____.

A. a many-sided plane figure   C. both A and B
B. bound by straight lines   D. neither A nor B

_____B_____ **24.** A trapezoid is a quadrilateral with _____ sides parallel.

A. no   C. opposite
B. two   D. all

_____A_____ **25.** The circumference of a sphere is equal to the circumference of a _____ circle.

A. great   C. either A or B
B. small   D. neither A nor B

(T)   F   **26.** In a formula, the sign of a number or letter is changed to the opposite sign when transposed.

(T)   F   **27.** Angles are measured in degrees, minutes, and seconds.

T   (F)   **28.** Supplementary angles are two angles formed by three lines in which the sum of the two angles equals 90°.

T   (F)   **29.** A chord is a line from circumference to circumference through the centerpoint of a circle.
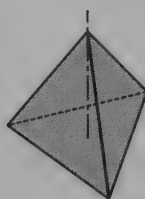
(T)   F   **30.** A sector is a pie-shaped piece of a circle.
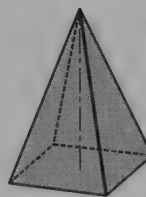
Pyramids

_____B_____ **1.** Right rectangular

_____A_____ **2.** Right triangular

_____C_____ **3.** Oblique pentagonal

(A)   (B)   (C)

Quadrilaterals

_____F_____	**1.** Trapezium
_____A_____	**2.** Trapezoid
_____A_____	**3.** Square
_____B_____	**4.** Rectangle
_____C_____	~~**5.**~~ Rhombus
_____D_____	~~**6.**~~ Rhomboid
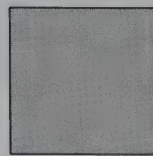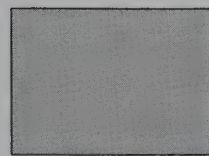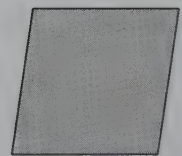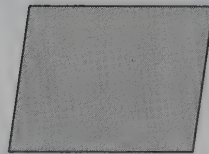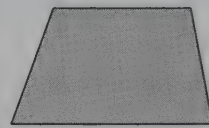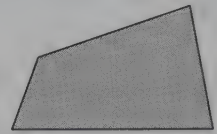
Regular Solids

_____T_____	**1.** Tetrahedron
_____B_____	**2.** Hexahedron
_____C_____	**3.** Octahedron
_____D_____	**4.** Dodecahedron
_____A_____	**5.** Icosahedron
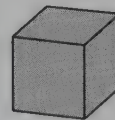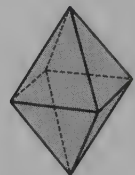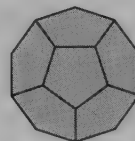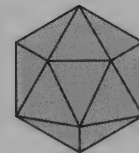
Other Regular Solids

_____C_____	~~**1.**~~ Oblate ellipsoid
_____D_____	~~**2.**~~ Prolate ellipsoid
_____B_____	~~**3.**~~ Torus
_____A_____	~~**4.**~~ Sphere
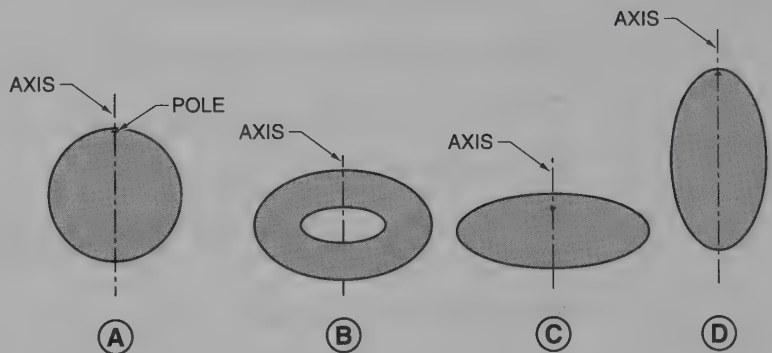
Conic Sections

_____D_____	~~**1.**~~ Circle
_____A_____	~~**2.**~~ Ellipse
_____C_____	~~**3.**~~ Parabola
_____B_____	~~**4.**~~ Hyperbola
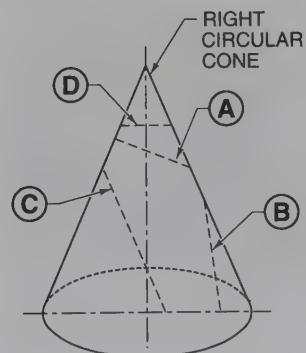
Problems

_50.75_

1. The area of Rectangle A is _____ sq in.

RECTANGLE A

3.5″

14.5″
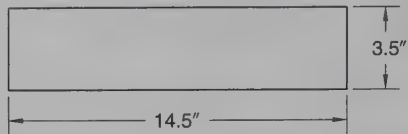
_2000_

2. The Warehouse contains _____ sq ft.

WAREHOUSE

40′

40′

20′

60′
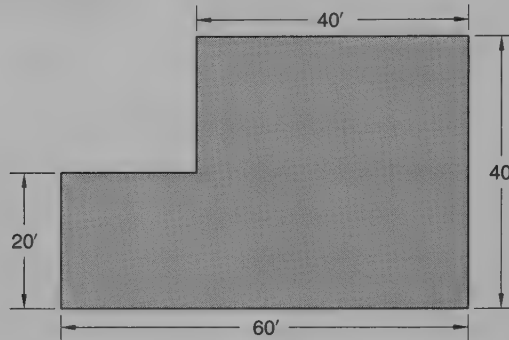
_1600_
_400_
_2000_

_25.13_ **3.** The circumference of Circle A is _____ ′.

_50.27_ **4.** The area of Circle A is _____ sq ft.

_120_ **5.** The area of Triangle A is _____ sq in.

_11.66_ **6.** The length of Side c of Triangle A is _____ ″.
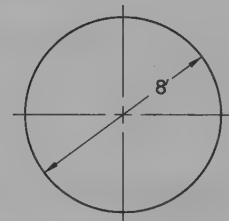
_78.54_ **7.** The area of Circle B is _____ mm².

_31.42_ **8.** The circumference of Circle B is _____ mm.

_615.75_ **9.** A circle has a 28″ diameter. The arc of the circle is _____ sq in.
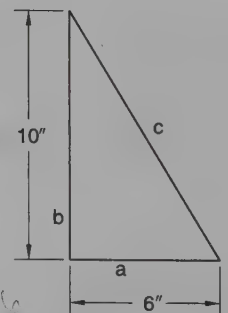
_593.76_ **10.** The Outer Zone contains _____ sq ft.
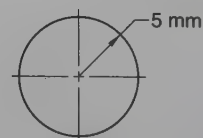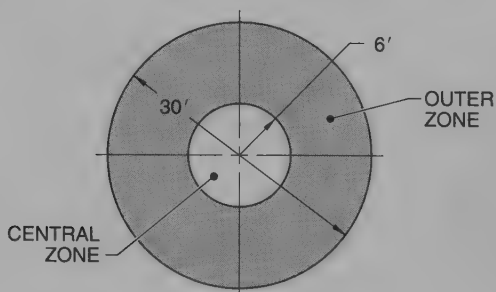
8′

CIRCLE A

10″

c

b

a

6″

TRIANGLE A

_136_   _108_

_96_

5 mm

CIRCLE B

6′

30′

OUTER ZONE

CENTRAL ZONE

_706.86_
_- 113.10_
_593.76_

Rigging

Name _____ Date _____

Industrial Mechanics

Rigging   **1.** _____ is securing equipment or machinery in preparation for lifting by means of rope, chain, or webbing.

Symmetrical   **2.** A(n) _____ load is a load in which one-half of the load is a mirror image of the other half.

lug   **3.** A lifting _____ is a thick metal loop (eyebolt) welded or screwed to a machine to allow balanced lifting.

Ⓣ   F   **4.** The sling apex is the uppermost point where sling legs meet.

Ⓣ   F   **5.** Rope is used for lifting because of its length and flexibility.

lay   **6.** Rope _____ is the length of rope in which a strand makes a complete helical wrap around the core.

Acid   **7.** A(n) _____ is any kind of a class of sour substances with a pH value less than 7.

thimble   **8.** A(n) _____ is a curved piece of metal around which the rope is fitted to form a loop.

T   Ⓕ   **9.** A socket is a rope attachment through which a rope end is terminated.

T   Ⓕ   **10.** Because a rope is flexible, bending does not subject it to stress.

Ⓣ   F   **11.** Fiber rope can be made from either natural or synthetic fibers.

B   **12.** A _____ is the interlacing of rope to form a permanent connection.
    A. hitch   C. bight
    B. knot   D. neither A, B, nor C

C   **13.** _____ is a knitted or woven edge of a webbing formed to prevent raveling.
    A. Web ply   C. Selvedge
    B. Rebanding   D. Loop eye

tempering   **14.** _____ is the process in which metal is brought to a temperature below its critical temperature and allowed to cool slowly.

Shear   **15.** _____ strength is a metal's resistance to a force applied parallel to its contacted plane.

Alloy   **16.** A steel _____ is a metallic material formulated from the fusing of two or more metals.

Warrington   **17.** _____ wire is a wire rope constructed of strands consisting of more than one size wire staggered in layers.

splice **18.** A(n) _____ is the joining of two rope ends to form a permanent connection.

length **19.** The web sling _____ is the distance between the extreme points of a web sling, including any fittings.

shackle **20.** A(n) _____ is a U-shaped metal link with the ends drilled to receive a pin or bolt.

_5_ **21.** Regarding wire rope, a strength safety factor of _____ is used for steady or even loads.

T   F   **22.** Fiber core wire rope slings of all grades shall be permanently removed from service if they are exposed to temperatures exceeding 150°F.

(T)   F   **23.** A scaffold hitch is made from a clove hitch and a bowline knot.

T   (F)   **24.** The NACM specifies that the grade number or letter of a chain must appear at least once every 48 links.

(T)   F   **25.** Hitches work by the pressure of rope being pressed together.

Hooks

_E_   **1.** Swivel

_A_   **2.** Gated

_B_   **3.** Ungated

_F_   **4.** Mousing

_D_   **5.** Eye

_C_   **6.** Clevis

Rigging Hardware Attachments

_G_   **1.** Shackle

_A_   **2.** Eyebolt

_E_   **3.** Chain

_F_   **4.** Hook

_D_   **5.** Thimble

_B_   **6.** Rope

_C_   **7.** Clip

_I_   **8.** Choker fitting

_H_   **9.** Webbing
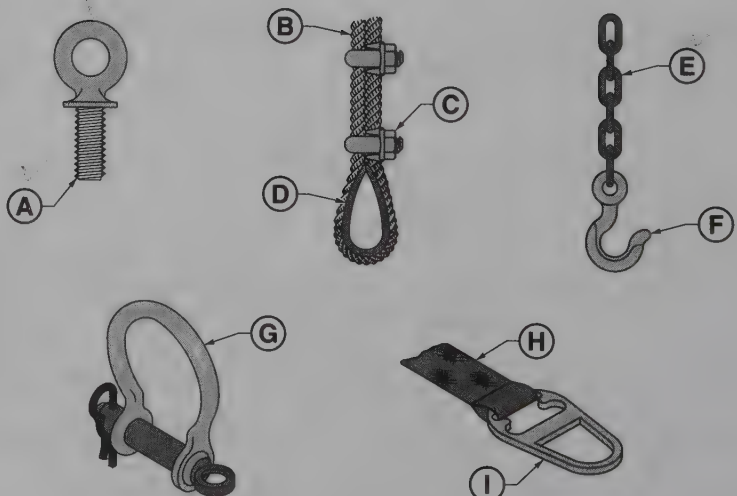
Wire Rope Terminations

_____ H   **1.** Wedge socket

_____ E   **2.** Open speltered socket

_____ F   **3.** Closed speltered socket

_____ G   **4.** Closed swaged socket

_____ A   **5.** Thimble

_____ C   **6.** Thimble and link

_____ D   **7.** Thimble and shackle

_____ B   **8.** Thimble and hook

Webbing

_____ H   **1.** Tapered eye

_____ E   **2.** Loop eye length

_____ J   **3.** Eye width

_____ D   **4.** Sling width

_____ A   **5.** Web face

_____ C   **6.** Selvedge

_____ G   **7.** Splice

_____ B   **8.** Warning core

_____ F   **9.** Body

_____ I   **10.** Length
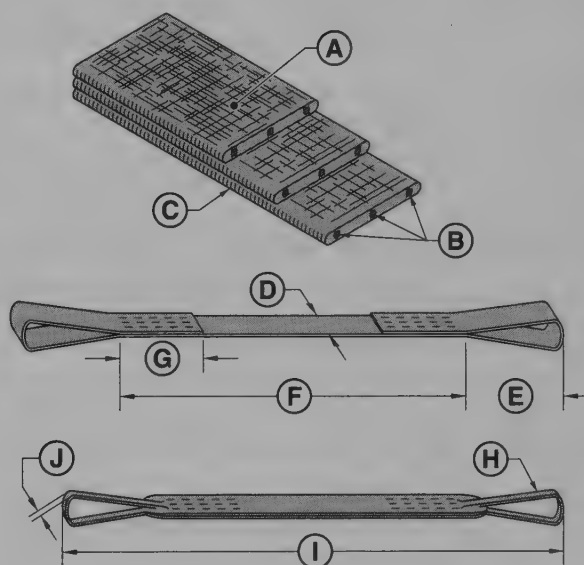
Chain Inspection

_____ E   **1.** Bent links

_____ D   **2.** Cracks

_____ C   **3.** Stretching

_____ B   **4.** Excessive wear

_____ A   **5.** Gouges
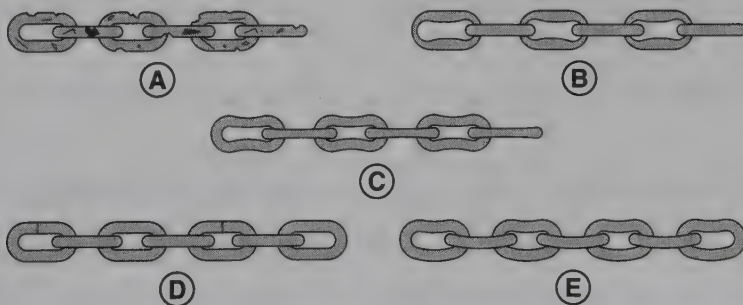
Problems

Refer to appropriate tables in Appendix.

_____ 7.18 **1.** The pieces of 1¾″ D round steel weigh _____ lb.
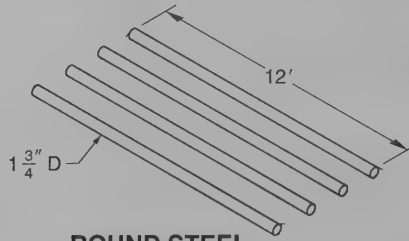
ROUND STEEL

_____ 39.01 **2.** Three 10′ pieces of ¼″ D round steel and one 10′ piece of 1″ square steel weigh _____ lb.

_____ 5875 **3.** An order for twenty-four 36″ × 96″ sheets of ¼″ steel plate weighs _____ lb.

_____ .766 **4.** The loss factor is _____° if the sling angle is 50° from the horizon.

_____ .9352 **5.** The total lifting capacity of a two-leg sling made of ¼″, 6 × 19, IPS-FC wire rope with the sling loops constructed of swaged sockets and sling angles of 60° is _____ t.

_____ 1600 **6.** The rope bending load rating of a ½″ rope traveling over an 8″ pulley with a load rating of 1800 lb is _____ lb.

_____ 25,000 lb **7.** The generally accepted safe rope strength to lift 5000 lb with a steady lift is _____.

_____ 4115.2 lb **8.** The lifting capacity of a basket hitch using a 1½″ wide Class 5, Type V endless sling without fittings and having a 40° sling angle is _____ lb.

_____ 25732.6 lb **9.** The lifting capacity of a round sling basket hitch with a yellow cover and 50° sling angle is _____ lb.

_____ Yes **10.** Should the used chain be removed from service?
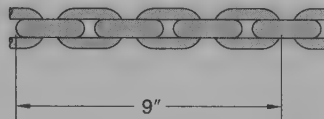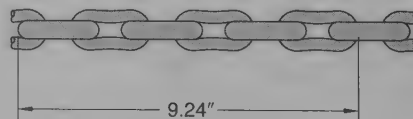
NEW CHAIN   **USED CHAIN**

Rigging

Chapter 2
Test 2

Name _____   Date _____

Industrial Mechanics

Lifting   **1.** _____ is hoisting equipment or machinery by mechanical means.

Asymmetrical   **2.** A(n) _____ load is a load in which one-half of the load is not a mirror image of the other half.

Center of gravity   **3.** The _____ is the balancing point of a load.

hortizontal   **4.** The _____ weight center is a weight mass above a pivot point that causes a load to topple because it is too heavy.

sling   **5.** A(n) _____ is a line consisting of a strap, chain, or rope used to lift, lower, or carry a load.

_D_   **6.** Fiber rope is constructed by twisting _____.

    A. fibers into yarn   C. strands into rope
    B. yarn into strands   D. A, B, and C

alkali   **7.** A(n) _____ is a bitter substance with a pH value greater than 7.

whipping   **8.** _____ is the wrapping placed around all strands of a rope near the area where the rope is cut.

T   F   **9.** A hitch is the interlacing of rope to temporarily secure it without knotting the rope.

T   (F)   **10.** A bowline knot is a knot that forms a loop which slips along the rope from which it is made.

T   F   **11.** A wagoneer's hitch knot is a knot that creates a load-securing loop from the standing part of the rope.

_C_   **12.** A timber hitch is _____.

    A. a binding knot and hitch combination   C. either A or B
    B. used to wrap and drag lengthy material   D. neither A nor B

tensile   **13.** _____ strength is a measure of the greatest amount of straight-pull stress metal can bear without tearing apart.

bending   **14.** _____ strength is a metal's resistance to deflection in the direction in which the load is applied.

outside   **15.** The diameter of wire rope is determined by the largest possible _____ dimension.

Seale   **16.** _____ wire is wire rope that uses different size wire in different layers.

cabling   **17.** _____ is a rope's attempt to rotate and untwist its strand lays while under stress.

lay   **18.** A(n) _____ is a complete helical wrap of the strands of a rope.

eye loop   **19.** A(n) _____ is a rope splice containing a thimble.

loop eye   **20.** The _____ of a web sling is a length of webbing folded back and spliced to the sling body, forming an opening.

wear   **21.** A(n) _____ pad is a leather or webbed pad used to protect the web sling from damage.

_____   **22.** A(n) _____ sling is a sling consisting of one or more continuous polyester fiber yarns wound together to make a core.

Chain   **23.** A(n) _____ is a series of metal rings connected to one another and used for support, restraint, or transmission of mechanical power.

_8_   **24.** Regarding wire ropes, a strength safety factor of _____ is used for shock or uneven loads.

Types   **25.** Basic web slings are fabricated in six configurations, which are _____ I through VI.

Rope Lay

Right   **1.** A(n) _____-lay is shown at A.

Left   **2.** A(n) _____-lay is shown at B.

Right lang   **3.** A(n) _____-lay is shown at C.

Left lang   **4.** A(n) _____-lay is shown at D.
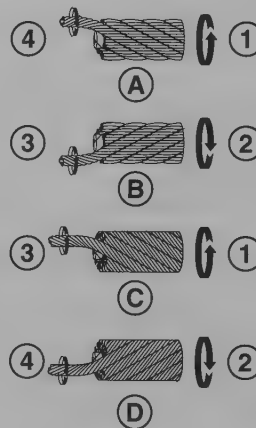
(4) (A) (1) — STRANDS TWISTED IN CLOCKWISE ROTATION

(3) (B) (2) — STRANDS TWISTED IN COUNTERCLOCKWISE ROTATION

(3) (C) (1) — YARN OR WIRES TWISTED IN CLOCKWISE ROTATION

(4) (D) (2) — YARN OR WIRES TWISTED IN COUNTERCLOCKWISE ROTATION

Rope Terminology

_J_   **1.** Loop

_I_   **2.** Kink

_A_   **3.** Standing part

_C_   **4.** Standing end

_F_   **5.** Working part

_B_   **6.** Whipping

_D_   **7.** Bight

_E_   **8.** Nip

_G_   **9.** Eye loop

_H_   **10.** Working end
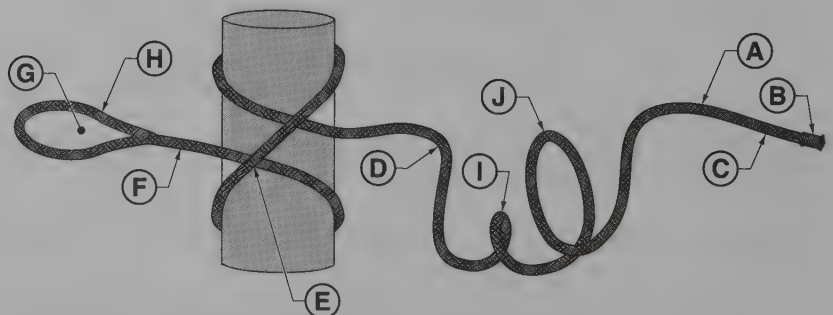
Hoisting Hooks

C	**1.** Foundry
B	**2.** Choker
D	**3.** Swivel
A	**4.** Grab
E	**5.** Sorting

(A) (B) (C) (D) (E)
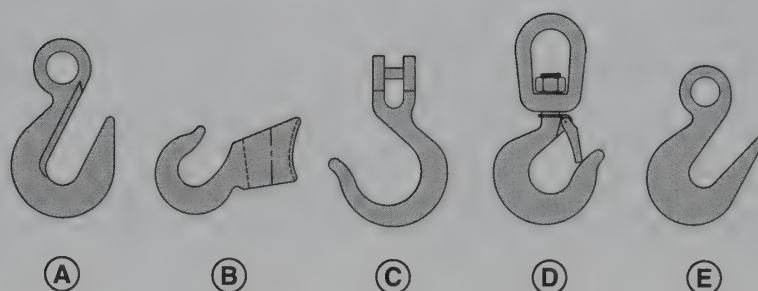
Basic Sling Combinations

A	**1.** Basket
C	**2.** Bridle
B	**3.** Choker
D	**4.** U
E	**5.** Vertical (single-leg)

(A) (B) (C) (D) (E)
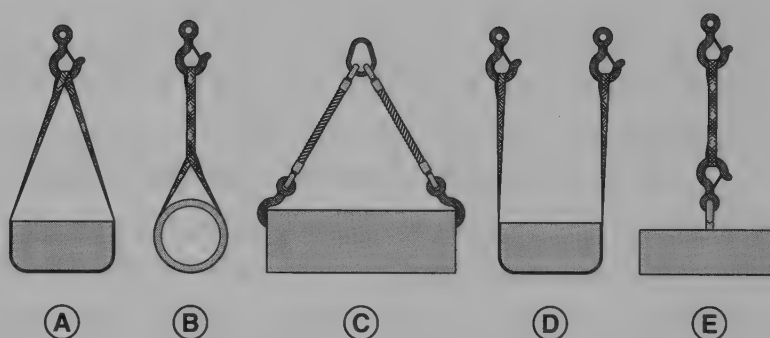
Slings

B	**1.** Type I
A	**2.** Type II
D	**3.** Type III
C	**4.** Type IV
E	**5.** Type V
F	**6.** Type VI

TRIANGLE FITTINGS

(A)

TRIANGLE FITTING — SLOTTED TRIANGLE CHOKER FITTING — LENGTH

(B)

LOOPS AT 90° WITH SLING BODY — SLING BODY

(C)

FLAT LOOPS IN SAME PLANE WITH SLING BODY

(D)

CONTINUOUS LOOP

(E)

LOOPS AT 90° WITH SLING BODY — WEAR PAD

(F)
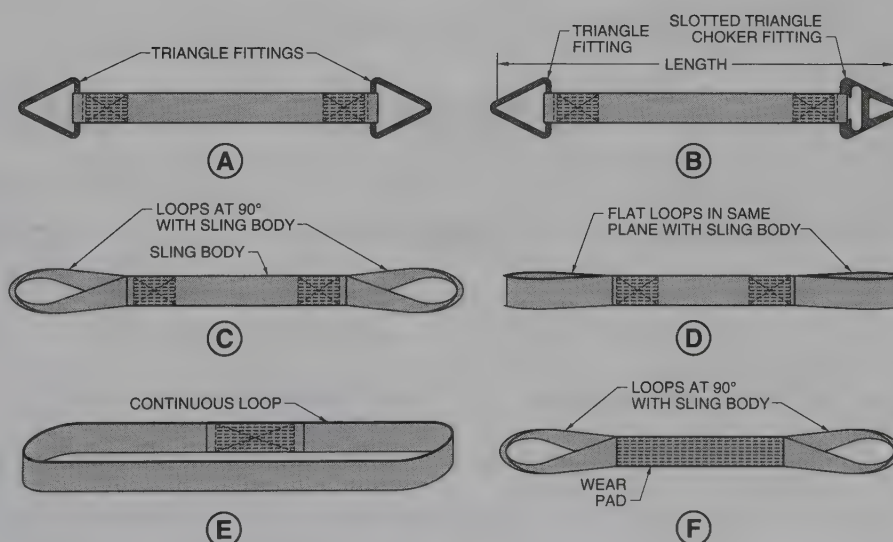
Problems

Refer to appropriate tables in Appendix.

_226 lb_ **1.** The 10′ pieces of 1 ¼″ D brass weigh _____ lb.

225 lb
1 SC

BRASS

$1\frac{1}{4}$″ D

10′
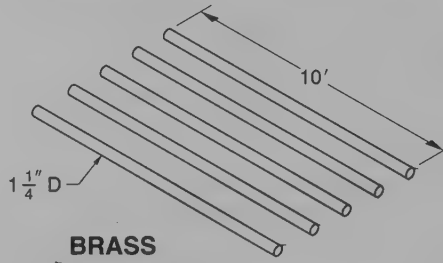
_361 lb_ **2.** Fifteen 10′ pieces of ¾″ D round steel and four 10′ pieces of 1″ square steel weigh _____ lb.

_9139.2_ **3.** Twenty-eight 48″ × 96″ sheets of ¼″ steel plate weighs _____ lb.

_.906_ **4.** The loss factor is _____° if the sling angle is 65° from the horizon.

_1,8236+_ **5.** The total lifting capacity of a two-leg sling made of ⅜″, 6 × 19, IPS-FC wire rope with the sling loops constructed of wedged sockets and sling angles of 70° is _____ t.

_1305_ **6.** The rope bending load rating of a ½″ rope traveling over a 6″ pulley with a load rating of 1500 lb is _____ lb.

_15000_ **7.** The generally accepted safe rope strength to lift 3000 lb with a steady lift is _____.

_4902.4_ **8.** The lifting capacity of a basket hitch using a 1 ½″ wide Class 5, Type V endless sling without fittings and having a 50° sling angle is _____ lb.

_29,976.8 lb_ **9.** The lifting capacity of a round sling basket hitch with a tan cover and 45° sling angle is _____ lb.

_No_ **10.** Should the used chain be removed from service?

| ← 8″ → |
| **NEW CHAIN** |

| ← 8.08″ → |
| **USED CHAIN** |

8 9C
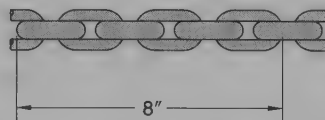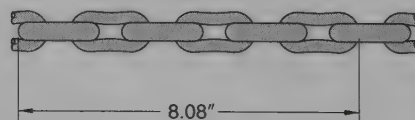
Lifting

Chapter 3
Test 1

Name _____   Date _____

Industrial Mechanics

Lifting **1.** _____ is the hoisting of equipment or machinery by mechanical means.

B **2.** A _____ is a rope length between the lower block and the upper block of a block and tackle.
   A. piece
   B. part
   C. portion
   D. neither A, B, nor C

B **3.** A _____ line is the part of the rope to which force is applied to hold or move a load.
   A. load
   B. lead
   C. front
   D. back

advantage **4.** Mechanical _____ is the ratio of the output force of a device to the input force.

T   F   **5.** The nominal bending strength of the most heavily loaded rope in a system shall be no less than 2½ times the load applied to that rope.

(T)   F   **6.** Torque is the twisting (rotational) force of a shaft.

T   F   **7.** In a bevel gear, the drive gear is the smaller gear.

(T)   F   **8.** Ambient temperature is the temperature of the air surrounding a piece of equipment.

Pendant **9.** A(n) _____ is a pushbutton or lever control suspended from a crane or hoisting apparatus.

C **10.** The proper direction for winding the first layer of rope on a drum is determined by the _____ of the rope.
   A. length
   B. diameter
   C. lay
   D. neither A, B, nor C

forged **11.** The two basic types of eyebolts are formed steel and _____ steel.

T   (F)   **12.** As a sling moves from a vertical to an angular position, the capacity of the eyebolt is increased.

(T)   F   **13.** All crane pulls should be vertical.

eyebolt **14.** A(n) _____ is a bolt with a looped head.

block **15.** A(n) _____ is an assembly of hooks, pulleys, and frames suspended by hoisting ropes.

Reeving **16.** _____ is passing a rope through a hole or opening or around a series of pulleys.

D **17.** A(n) _____ chain is the chain that raises the load.
   A. pull
   B. lift
   C. pickup
   D. hoist

_____C_____ **18.** The _____ hook is the hook assembled to the top of a hoisting mechanism to allow for overhead suspension.

    A. main   C. top
    B. overhead   D. master

_____B_____ **19.** Lever-operated hoists are generally used to lift loads that weigh from _____ lb to _____ lb.

    A. 100; 300   C. 300; 600
    B. 200; 500   D. neither A, B, nor C

_____pawl_____ **20.** A(n) _____ is a mechanism used to prevent the ratchet wheel of a lever-operated hoist from turning backwards.

_____pneumatic_____ **21.** A(n) _____ hoist is a power-operated hoist operated by a geared reduction air motor.

_____wrap_____ **22.** Drum _____ is the rope length required to make one complete turn around the drum of a hoist or crane.

_____hook drift_____ **23.** Hoist _____ is the slippage of a hook caused by insufficient braking.

_____25%_____ **24.** Typical eyebolt angular lift capacity is calculated using a constant of _____ for sling angles of less than 45°.

_____Gantry_____ **25.** A(n) _____ crane is a crane with bridge beams supported on legs.

Bevel Gear

_____H_____ **1.** Slip clutch

_____E_____ **2.** Hoist chain

_____B_____ **3.** Bearing

_____G_____ ~~**4.**~~ Drive gear _driven_

_____D_____ **5.** Endless hand chain

_____C_____ **6.** Beveled gears

_____F_____ **7.** Load

_____A_____ ~~**8.**~~ Drive gear
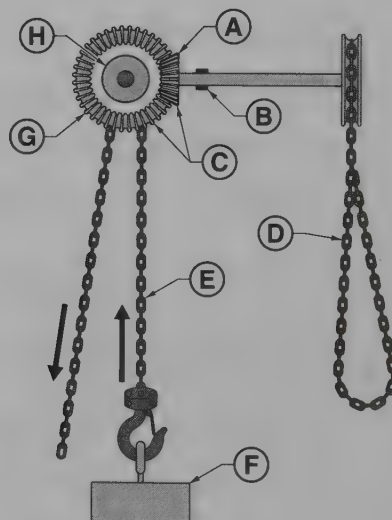
Drum Wrap

_____A_____ **1.** Underwind left to right

_____C_____ **2.** Overwind left to right

_____B_____ **3.** Underwind right to left

_____D_____ **4.** Overwind right to left
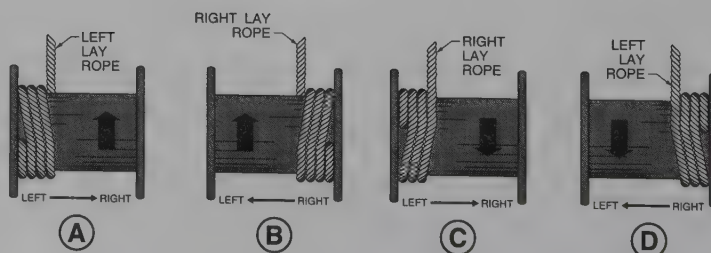
Safety

__D__	**1.** OSHA	**A.** Publishes the National Electrical Code®, which contains standards for the practical safeguarding of persons and property from the hazards arising from the use of electricity.
__C__	**2.** ANSI	
__B__	**3.** ISO	**B.** Nongovernmental international organization comprised of national standards institutions of over 90 countries.
__E__	**4.** CMAA	**C.** U.S. standards-developing organization that adopts and co-publishes standards that are written and approved by member organizations.
__F__	**5.** ASME	
__A__	**6.** NFPA	**D.** U.S. government organization concerned with the development and enforcement of safety standards for industrial workers.

E. Organization of crane manufacturers that promotes standardization and establishes crane-operating practice standards.

F. Organization that helps establish safe structural design of hoists and cranes and sets safety standards.

Crane Hand Signals

__G__	**1.** Raise boom
__H__	**2.** Lower boom
__K__	**3.** Raise boom and lower load
__L__	**4.** Lower boom and raise load
__C__	**5.** Trolley travel
__D__	**6.** Multiple trolleys
__E__	**7.** Stop
__F__	**8.** Emergency stop
__J__	**9.** Move slowly
__I__	**10.** Bridge travel
__A__	**11.** Hoist
__B__	**12.** Lower
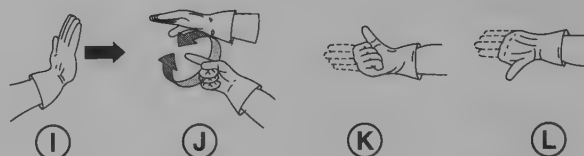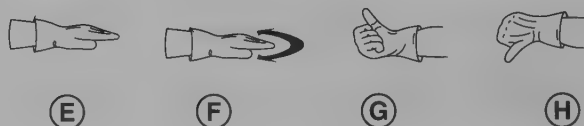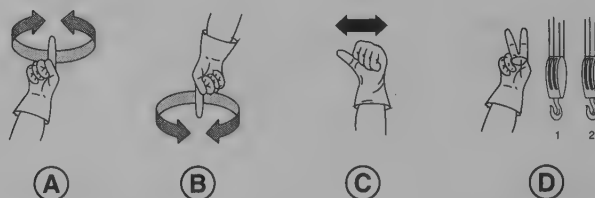
Jib Cranes

__A__	**1.** Wall-mounted, top-braced
__B__	**2.** Wall-mounted, cantilevered
__D__	**3.** Mast, cantilevered
__E__	**4.** Mast, underbraced
__F__	**5.** Mast, top-braced
__C__	**6.** Base-mounted, cantilevered
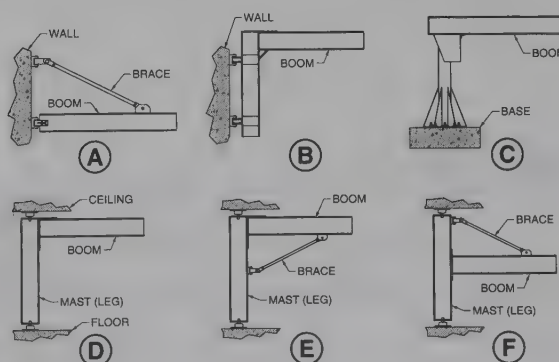
Hand-Chain Hoists

_____ D _____   **1.** Hoist chain

_____ F _____   **2.** Lower limit of hoist hook travel

_____ C _____   **3.** Upper limit of hoist hook travel

_G_ ⊘ _____   **4.** Hoist hook

_____ J _____   **5.** Reach

_____ K _____   **6.** Pocket wheel

_____ A _____   **7.** Top hook

_____ H _____   **8.** Hand chain

_____ B _____   **9.** Head room

_____ E _____   **10.** Lift

_____ I _____   **11.** Hand chain drop
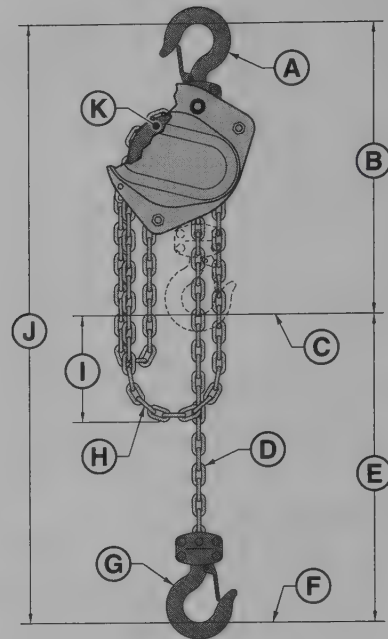
Problems

_____ 200 _____   **1.** A force of _____ lb is required to hold a 600 lb load using a three-part reeving system.

4' ⊘   **2.** Under ideal conditions, the lead line at A requires a pull of _____ ' to lift the 100 lb load.

25 lb ⊘   **3.** Under ideal conditions, the lead line at A requires a force of _____ lb to lift the 100 lb load.

_____ 984 _____ '   **4.** A force of _____ lb is required to move an 8000 lb load using a 10-part reeving system equipped with rolling-contact bearing pulleys. ℓ ᴄᴄ

_____ 1090 lb _____   **5.** A(n) _____ lb force is required to move a 1000 lb load using one-part reeving and plain bearing pulleys.

_____ 27.5 _____   **6.** The minimum compressor size required for a pneumatic hoist that requires 110 scfm is _____ HP. 2500

1143 ⊘   **7.** The working load capacity of a 40° bridle sling using a ⅝″ shoulder nut eyebolt is _____ lb. 3500 × .2
     From
     .643 - Page 25

⊘   **8.** The working load of a 60° bridle sling using a ¼″ shoulder nut eyebolt is _____ lb.
     500 × 70

144.34

500 × .25
     Table p.78

.866 Constant
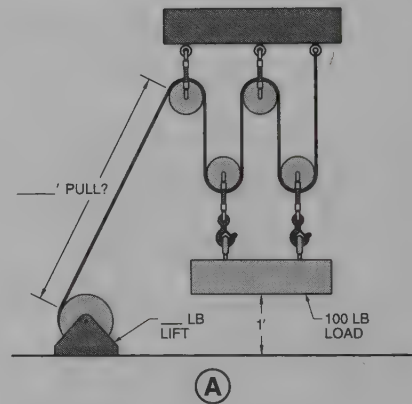
Ladders and Scaffolds

Chapter 4
Test 1

Name __Randy Stein__   Date _____

Industrial Mechanics

__B__   **1.** A heavy-duty, industrial, 250 lb capacity ladder has a Type _____ rating.
- A. IA
- B. I
- C. II
- D. III

__B__   **2.** Fixed ladders are installed in a preferred pitch range between _____° and 90° from horizontal.
- A. 45
- B. 60
- C. 75
- D. neither A, B, nor C

__4'__   **3.** Metal ladders should not be used within _____' of electrical circuits or equipment.

__aluminum__   **4.** Most metal ladders are constructed of _____, which is a relatively light metal.

T   (F)   **5.** Fiberglass ladders conduct electricity when dry.

(T)   F   **6.** A fixed ladder is permanently attached to a structure.

__Extension__   **7.** A(n) _____ ladder is an adjustable-height ladder with a fixed bed section and sliding, lockable fly section(s).

__10__   **8.** All scaffolds _____' or more above ground must have guardrails, midrails, and toeboards.

__C__   **9.** Guardrails on scaffolds must be installed no less than _____" or more than _____" high, with a midrail.
- A. 24; 30
- B. 30; 36
- C. 36; 42
- D. 42; 48

__A__   **10.** Nails smaller than _____d common must not be used to construct scaffolds.
- A. 8
- B. 10
- C. 12
- D. 16

__B__   **11.** A safety net must be used anywhere a person is working _____' or more above ground, water, machinery, etc. when the worker is not otherwise protected by a safety belt, lifeline, or scaffolding.
- A. 10
- B. 25
- C. 40
- D. 60

(T)   F   **12.** The minimum netting mesh size for bodily fall protection is normally 6" × 6".

T   (F)   **13.** Border rope for safety nets shall have a 2500 lb breaking strength when new.

(T)   F   **14.** A person should always face the ladder when ascending or descending.

(T)   F   **15.** Ladders are designed for use by only one person unless specifically designated otherwise.

Suspension 16. A(n) _____ scaffold is a scaffold supported by overhead wire ropes.

_20'_ 17. The maximum working height of a hydraulic scissor lift scaffold is _____'.

_2"×10"_ 18. Scaffold platform planks consist of _____" nominal structural planks.

Pole 19. A(n) _____ scaffold is a wood scaffold with one or two sides firmly resting on the floor or ground.

_B_ 20. Stepladders are commonly _____ in length.

   A. 2'-0" to 6'-0" C. 4'-0" to 8'-0"
   B. 2'-0" to 8'-0" D 4'-0" to 10'-0"

_C_ 21. The spacing between rungs of ladders, except for stepstools, shall be on _____" centers ± _____".

   A. 8; ⅛ C. 12; ⅛
   B. 8; ¼ D. 12; ¼

_4'_ 22. The overlap of the fly section of a 42' extension ladder shall be at least _____'.

Halyard 23. The _____ is the rope used for raising and lowering the fly sections of extension ladders.

_7"_ 24. The minimum distance between the center of the rung of a fixed ladder to the building wall is _____".

_50'_ 25. A cage, well, or ladder safety system must be provided where a single length of climb on a fixed ladder is greater than 24' but less than _____'.

duty 26. Ladder _____ rating is the weight (in lb) a ladder is designed to support under normal use.

III 27. A Type _____ stepladder is designed for light-duty, household use.

(T) F 28. Fixed ladders are commonly constructed of steel or aluminum.

(T) F 29. Single ladders are of fixed length having only one section.

T (F) 30. A mobile scaffold may be moved with a worker on the platform.

Sectional Metal-Framed Scaffolds

_G_ 1. Bearer

_E_ 2. Hook-on ladder

_C_ 3. Diagonal brace

_B_ 4. Cross brace

_D_ 5. Coupling tube

_F_ 6. Footing base plate
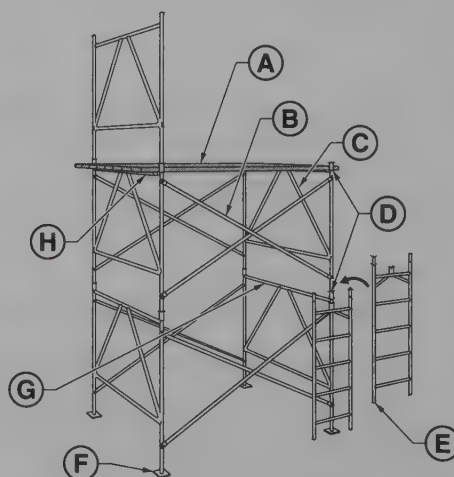
_H_ 7. Cleat

_A_ 8. Planking

Pole Scaffolds

D
H
I
K
G
A
F
B
C
J
E

1. Ledger
2. Cross brace
3. Diagonal brace
4. Planking
5. Footing
6. Guardrail
7. Upright
8. Midrail
9. Toeboard
10. Bearer
11. Splice

Ladder Jacks

E
B
A
D
E
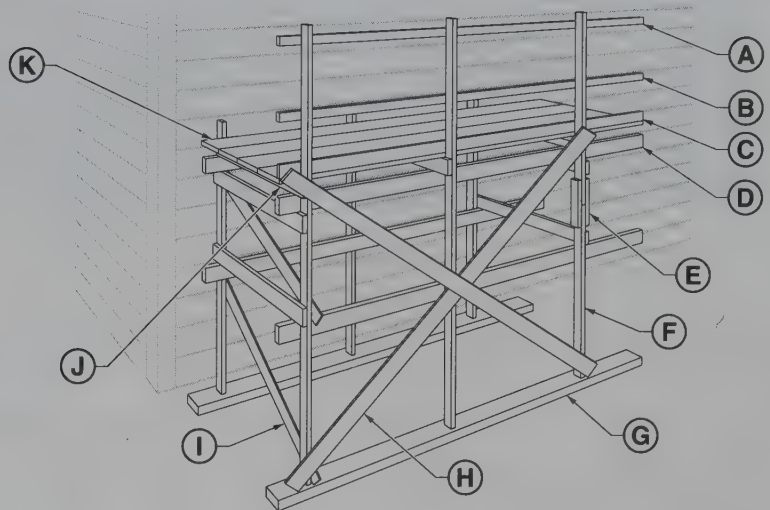
1. Hook
2. Ladder jack
3. Ladder
4. Plank
5. Hook

Extension Ladders

H
C
A
E
G
B
E
L
K
I
D
J
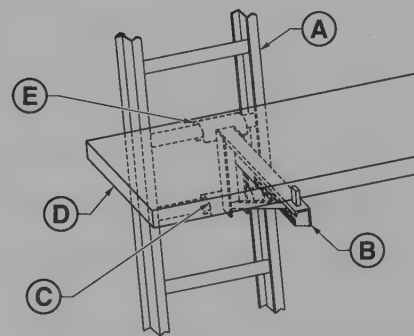
1. Halyard
2. Rungs
3. Tip
4. Butt end
5. Plastic rail closures
6. Center swivel pulley
7. Foot assembly
8. Flange
9. Web
10. Bed section
11. Pawl lock
12. Fly section
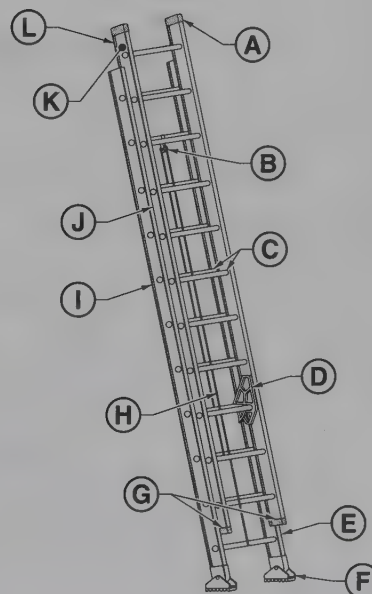
Pawl Locks

_____ A

_____ B

_____ C

1. The fly section of the ladder at _____ is held in place.

2. The fly section of the ladder at _____ is being lowered.

3. The fly section of the ladder at _____ is being raised.

SPRING BEING COMPRESSED

SPRING

PAWL

RUNG

RUNG

FINGER

Ⓐ   Ⓑ   Ⓒ
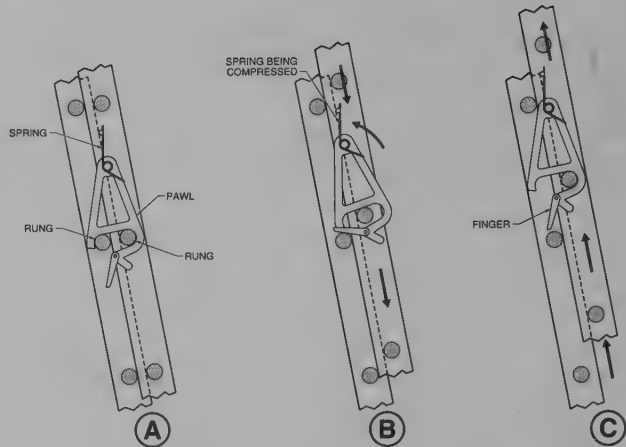
Problems

_____ 4'

_____ 5'

_____ 1"X6"

_____ 2"X4"

_____ 12'

_____ 5'

1. An extension ladder has a working height of 16'. The butt end of the ladder is placed _____' from the wall.

2. A 54' extension ladder shall have an overlap of at least _____'.

3. The braces of a medium-duty single-pole scaffold shall be constructed of _____ material.

4. Rails for light-duty double-pole scaffolds shall be constructed of _____ material.

5. The base of a scaffold measures 6' × 12'. The maximum height of the scaffold is _____'.

6. The minimum base dimension of the Mobile Scaffold is _____'.

1/2 height

10'

?
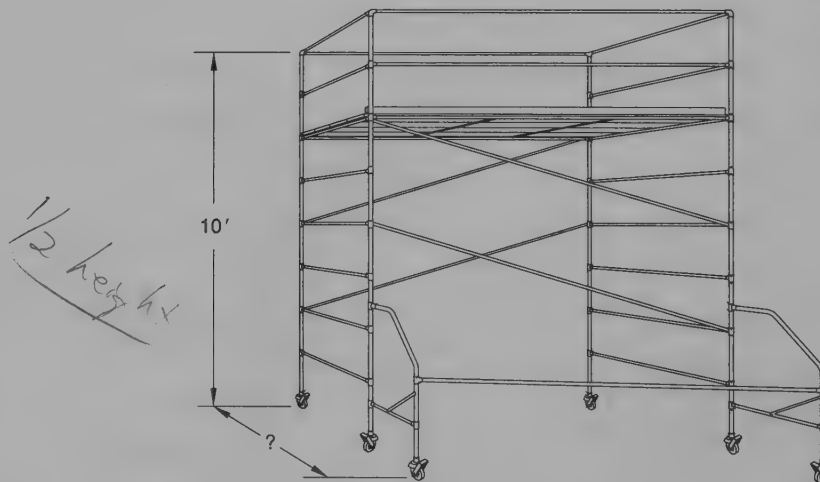
MOBILE SCAFFOLD

Hydraulic Principles

Chapter 5
Test 1

Name _____ Date _____

Industrial Mechanics

Hydraulics **1.** _____ is the branch of science that deals with the practical application of water or other liquids at rest or in motion.

Centrifugal **2.** _____ force is the outward force produced by a rotating object.

Gas **3.** A(n) _____ is a fluid that has neither independent shape nor volume and tends to expand indefinitely.

Pressure **4.** _____ is the force per unit area.

Kinetic **5.** _____ is the energy that produces movement.

14.7 **6.** The weight of the atmosphere at sea level is _____ psi.

inches Hg **7.** A mercury barometer is commonly calibrated in _____.

78.54 **8.** The area of a circle is _____% of the area of a square with the same measurement.

(T) F **9.** Area, force, and pressure are the basis of all hydraulic systems.

(T) F **10.** The pressure of the fluid in a vessel is the same at that level regardless of the shape of the vessel.

T (F) **11.** Fluids that are thin and flow easily have a high viscosity.

T (F) **12.** One gallon of fluid equals 321 cu in.

(T) F **13.** The velocity of a fluid decreases as the cross-sectional area of a pipe increases.

Vector **14.** A(n) _____ is a quantity that has a magnitude and direction.

Advantage **15.** Mechanical _____ is the ratio of the output force of a device to the input force.

Horse power **16.** _____ is a measure of the ability to do work.

C **17.** One horsepower is the amount of energy required to lift _____ lb 1′ in 1 min.
   A. 330
   B. 550
   C. 33,000
   D. 55,000

Work **18.** _____ is the energy used when a force is exerted over a distance.

(T) F **19.** Mineral-based oil is the most widely-used hydraulic fluid.

(T) F **20.** Static head pressure is potential energy.

_C_ **21.** _____ is the height at which atmospheric pressure forces a fluid above the elevation of its supply source.

    A. Increase   C. Lift
    B. Elevation   D. neither A, B, nor C

_C_ **22.** In a hydraulic system, _____.

    A. pressure provides force   C. both A and B
    B. flow rate provides speed   D. neither A nor B

T   (F)   **23.** Volume is the two-dimensional size of an object measured in cubic units.

(T)   F   **24.** Flow rate is the volume of fluid flow.

T   (F)   **25.** Static energy is the energy of motion.

Fluid Pressure

T   (F)   **1.** The pressure at A is twice the pressure at D.

(T)   F   **2.** The pressure at B is the same as the pressure at C.

(T)   F   **3.** The pressure at E is greater than the pressure at D.

T   (F)   **4.** The pressure at F is the same as the pressure at D.
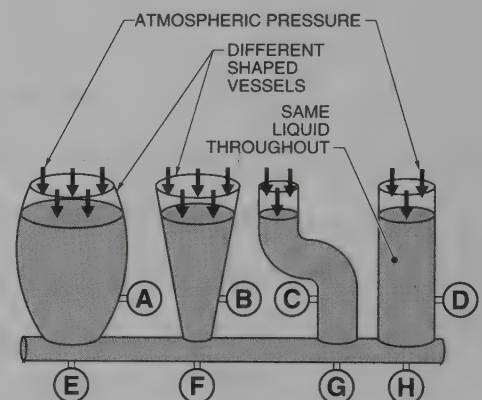
Lift

Static   **1.** _____ lift is shown at Tank A.

Dynamic   **2.** _____ lift is shown at Tank B.

TANK A   **TANK B**

Fluid Flow

_20_
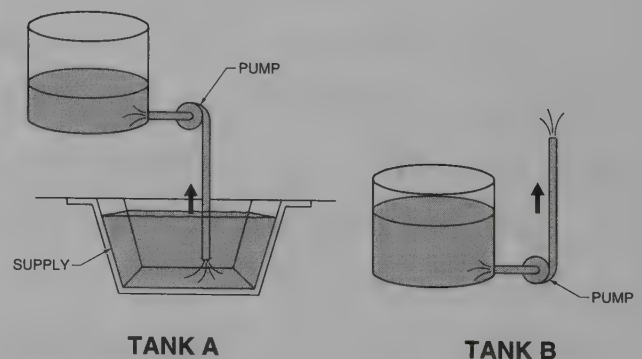
1. The fluid velocity at A is _____ ft/sec.
(Velocity is 4x greater in a pipe of ½ dia.)

_80_

2. The fluid velocity at B is _____ ft/sec.
(Velocity is 4x greater in a pipe of ½ dia.)

(T)   F   **3.** The fluid velocity at C is ¼ the fluid velocity at A.
_OK_   (Velocity is 4x greater in a pipe of ½ dia.)

1" ID PIPE VELOCITY
= 2.042 FT/SEC

(B) ¼" ID

FLOW RATE
= 5 GPM

(A) ½" ID

FLOW RATE
= 5 GPM

(C) 1" ID

Horsepower

_2.62_
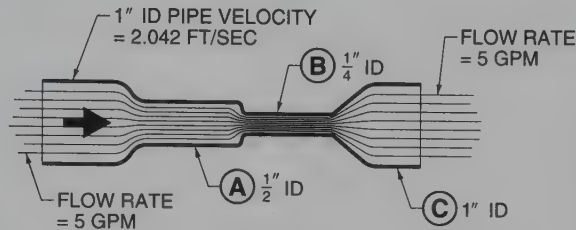
1. The horsepower required to lift Load A is _____ HP.

_2.18_

2. The horsepower required to lift Load B is _____ HP.

$\frac{600 \times 12}{530 \times 5}$

900 + 20
550 × 15

600 LB

5 SEC

12'

600 LB

LOAD A

900 LB

20'

15 SEC

900 LB

LOAD B
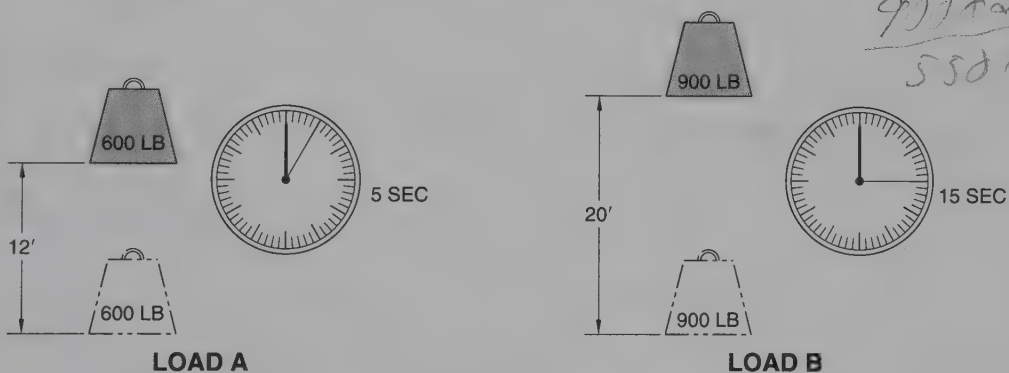
Problems

_7,875_

1. Tank C has a capacity of _____ cu ft.

_16_

2. Tank D has a capacity of _____ m³.

_109.2_

3. The absolute pressure in a system with a gauge pressure of 94.5 psig is _____ psia.

3.5'

1.5' SQ

(C)

2 m

4 m

2 m

(D)

× 3.5

_1.23_
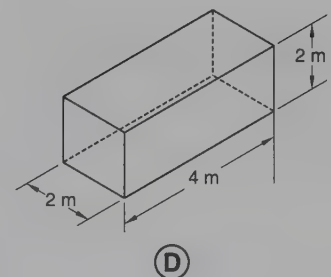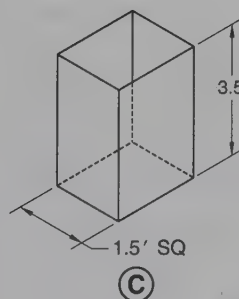
4. The area of Piston A is _____ sq in.

81.30 psi

5. A pressure of _____ psi is required to move a 100 lb force with Piston A.

_.75_

6. The amount of fluid required to fully extend a 3.5″ D cylinder with an 18″ stroke is _____ gal.

_500_

7. A force of _____ lb is produced by a 4 sq in. piston operating at 125 psi.

$P \times A$

_3.267_

8. The velocity of a fluid having a flow rate of 4.5 gpm through a 1′ section of ¾″ D pipe is _____ ft/sec.

_262.5_

9. The torque required to overcome the force at Winch A is _____ lb-in.

_393.75_

10. If the distance in Problem 9 was increased to 5.25″, _____ lb-in would be required to overcome the force.

_24 sq ″_

11. The area of Surface A on Block A is _____ sq in.

_.5_

12. The area of Surface B on Block A is _____ sq ft.

_144 cu in_

13. The volume of Block A is _____ cu in.

_4X_

14. The velocity in Pipe A is _____ times greater than the velocity in Pipe B.

_3.14″_

15. The area of Pipe A is _____ sq in.
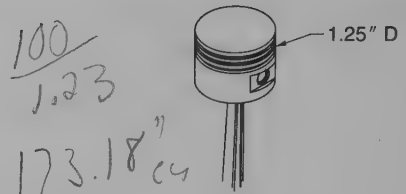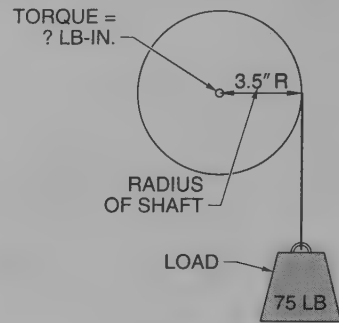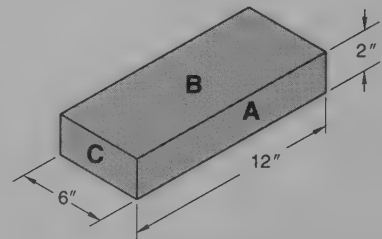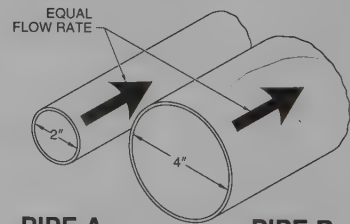
$\dfrac{100}{1.23}$

$173.18 \, cu$

PISTON A

— 1.25″ D

TORQUE = ? LB-IN.

3.5″ R

RADIUS OF SHAFT

LOAD

75 LB

WINCH A

75×3.5

B

A

C

2″

12″

6″

BLOCK A

EQUAL FLOW RATE

2″

4″

PIPE A   **PIPE B**

$\dfrac{1 \checkmark \quad \overset{x}{} \quad .5 \mid 2}{2}$

$14 \overset{4}{} \quad \dfrac{.44 \times 12}{231} \quad \dfrac{6.0}{4.5}$

Industrial Mechanics

Hydrostatics 1. _____ is the study of liquids at rest and the forces exerted on them or by them.

Equilibrium 2. _____ is the condition when all forces and torques are balanced by equal and opposite forces and torques.

Mercury barometer 3. A mercury _____ is an instrument that measures atmospheric pressure using a column of mercury.

Vacuum 4. _____ is a pressure lower than atmospheric pressure.

A 5. Area is always expressed in _____ units.
    A. square   C. either A or B
    B. cubic   D. neither A nor B

B 6. _____ lift is the lift of fluid in motion.
    A. Static   C. Head
    B. Dynamic   D. neither A, B, nor C

(T) F   7. Any friction generated in a hydraulic system becomes a resistance to fluid flow.

T (F)   8. The velocity of a fluid is constant as its speed or direction of flow changes from one moment to another.

(T) F   9. Total energy is a measure of a fluid's ability to do work.

Velocity 10. _____ is the distance a fluid travels in a specified time.

fulcrum 11. A(n) _____ is a support on which a lever turns or pivots and is located somewhere between the effort force and the resistance force.

Kinetic 12. _____ energy is the energy of motion.

torque 13. _____ is the twisting (rotational) force of a shaft.

Hydrodynamics 14. _____ is the study of the forces exerted on a solid body by the motion or pressure of a fluid.

Absolute 15. The _____ pressure is pressure above a perfect vacuum.

(T) F   16. Head is the difference in the level of a liquid between two points.

T (F)   17. Fluids that flow with difficulty have a low viscosity.

T (F) **18.** Capacity is expressed in square units.

_____ **19.** _____ torque is the energy that a motor develops to keep a load turning.

_____ **20.** One horsepower equals _____ lb/sec.

_____ **21.** _____ is the rate or speed of doing work.
    A. Energy   C. Capacity
    B. Power   D. Efficiency

_____ **22.** The viscosity _____ is a measure of the degree to which viscosity changes when a fluid is heated.
    A. rate   C. time
    B. index   D. temperature

_____ **23.** Fluid _flow_ is the movement of fluid caused by a difference in pressure between two points.

_____ **24.** _____ lift is the height to which atmospheric pressure causes a column of fluid to rise above the supply to restore equilibrium.

_____ **25.** _____ pressure is pressure above atmospheric pressure that is used to express pressures inside a closed system.

_____ **26.** A pressure gauge reads _____ psig at normal atmospheric pressure.

__C__ **27.** _____ head is the head of fluid in motion.
    A. Static   C. Dynamic
    B. Still   D. Divergent

_____ **28.** _____ is the volume of oil moved during each cycle of a pump.
    A. Residue   C. Load
    B. Displacement   D. neither A, B, nor C

_____ **29.** _____ is an increase in speed.

_____ **30.** _____ is a measure of a component's or system's useful output energy.
    A. Rate   C. Efficiency
    B. Percentage   D. Value

Hydrostatics

__D__ **1.** Heat energy

__A__ **2.** Static energy

__B__ **3.** Kinetic energy

__C__ **4.** Pressure energy
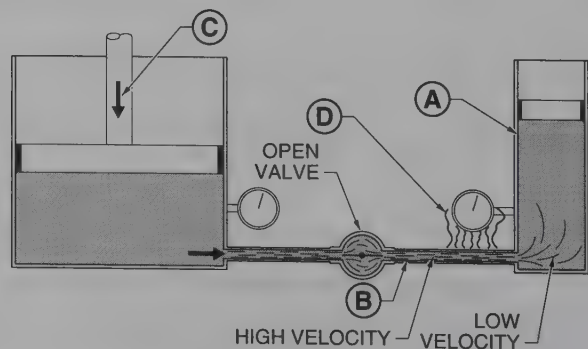
Mechanical Advantage

T (F)   **1.** Gear B will turn in a clock-
              wise direction.

T (F)   **2.** Gear B will turn twice as
              fast as Gear A.

(T) F   **3.** Gear B will turn with twice
              as much force as Gear A.

2″ D

4″ D

GEAR A

GEAR B
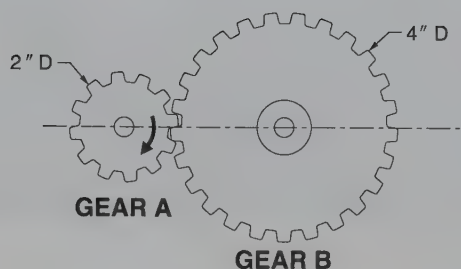
Problems

_____   **1.** The volume of Cylinder A is
                     _____ cu in.

_____   **2.** The volume of Cylinder B is
                     _____ mm³.

_____   **3.** The area of Piston A is _____
                     mm³.

10.5″ D

33″

CYLINDER A

11 mm

7 mm

CYLINDER B

50 mm D

PISTON A

_____   **4.** _____ gal. of fluid is required to fully re-
                     tract the piston in Cylinder A.

36″

PISTON

.75″ D

PISTON ROD

5″D

DIRECTION
OF TRAVEL

CYLINDER A
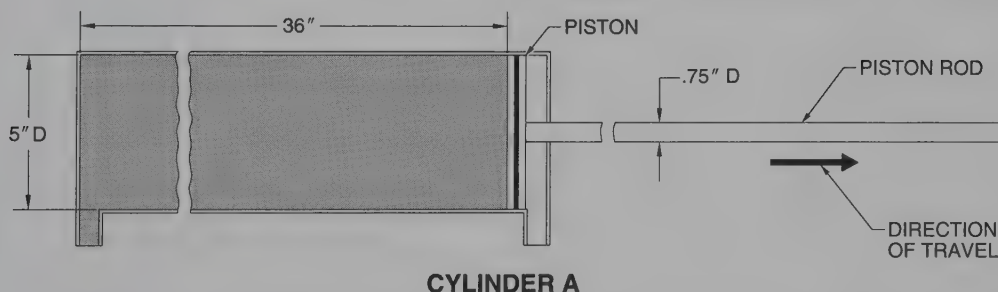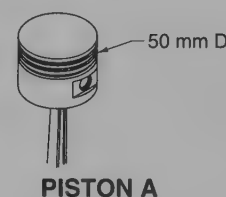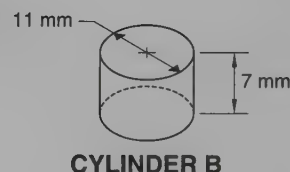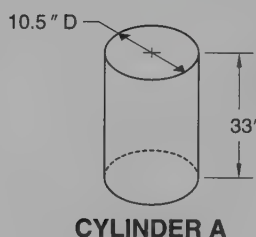
_____   **5.** A fluid particle in a hydraulic system travels 78′ from 10:20:05 AM to 10:20:47 AM. The
                     velocity of the fluid particle is _____ ft/sec.

_____   **6.** _____ lb of effort force is required
                     to lift the resistance force of Fulcrum A.

F_1 = ? LB F_2 = 1200 LB

_____   **7.** If the fulcrum in Fulcrum A were moved
                     2′ closer to F_2, and everything else re-
                     mained the same, _____ lb of ef-
                     fort force would be required to lift F_2.

F_2

d_1 = 20′ d_2 = 5′

FULCRUM A
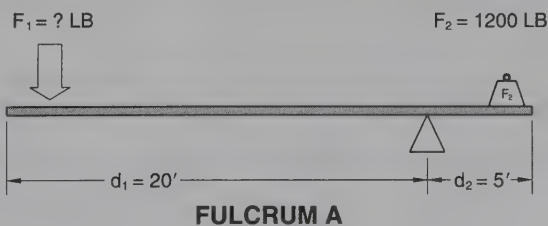
_____ **8.** The torque required to overcome the force at Winch A is _____ lb-in.

_____ **9.** If the load at Winch A was 120 lb, _____ lb-in would be required to overcome the force.

_____ **10.** The horsepower required to lift the 3 t load is _____ HP.

_____ **11.** If the 3 t load took 1 min to be lifted the 4′ distance, the horsepower required would be _____ HP.

T   F **12.** Load A requires more horsepower to be lifted than Load B.

TORQUE = ? LB-IN.

6″ R

LOAD

320 LB

WINCH A

3 T

10 SEC

4′

3 T

2000 LB

6 SEC

10′

2000 LB

LOAD A

2400 LB

6 SEC

8′

2400 LB
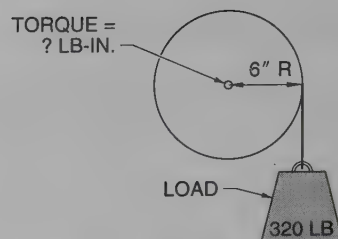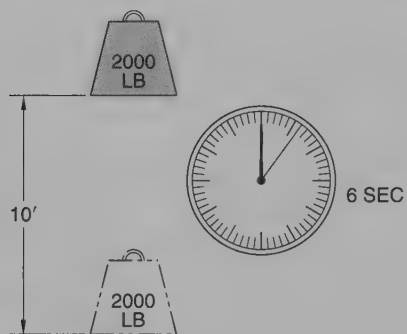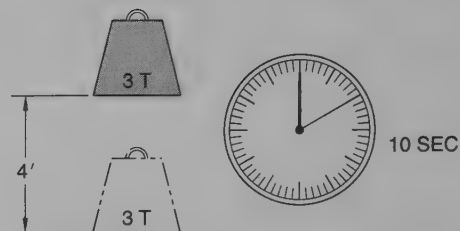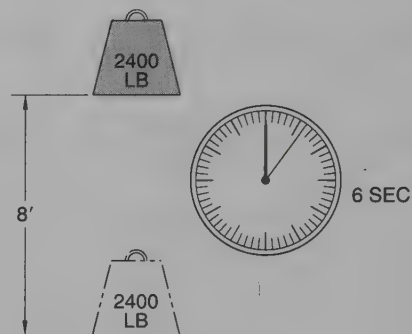
LOAD B

Practical Hydraulics

Chapter 6
Test 1

Name _____   Date _____

Industrial Mechanics

Liquid   **1.** A(n) *Liquid* is a fluid that can flow readily and assume the shape of its container.

cutaway   **2.** A(n) _____ diagram shows the internal details of components and the path of fluid flow.

Ⓣ F   **3.** Graphic symbols show flow paths, connections, and functions of components.

Ⓣ F   **4.** Hydraulic fluids lubricate moving parts of a circuit.

C   **5.** _____ is the combining of oxygen with elements in oil which break down the basic oil composition.
A. Foaming   C. Oxidation
B. Pitting   D. Cavitation

Pitting   **6.** _____ is localized corrosion that has the appearance of cavities.

T Ⓕ   **7.** Strainer screens are rated in microns and filters are rated in mesh.

T Ⓕ   **8.** A flared fitting is a fitting that is connected to a hose whose end is spread outward.

Ⓣ F   **9.** The higher the mesh number of a strainer, the smaller the opening.

Cylinder   **10.** A hydraulic _____ is a device that converts hydraulic energy into straight-line (linear) energy.

Squares   **11.** For graphic symbols used in hydraulic circuits, _____ generally represent values.

Foaming   **12.** _____ is excessive air in hydraulic fluid.

flash point   **13.** The _____ is the temperature at which oil gives off enough gas vapor to ignite briefly when touched with a flame.

C   **14.** A _____ filter is positioned in a hydraulic circuit just before the reservoir.
A. suction   C. return-line
B. pressure   D. neither A, B, nor C

B   **15.** A _____ is a device that transfers heat through a conducting wall from one fluid to another.
A. fin cooler   C. both A and B
B. heat exchanger   D. neither A nor B

Pipe   **16.** A(n) _____ is a hollow cylinder of metal or other material of substantial wall thickness.

Ⓣ F   **17.** Tubes may be connected by soldering, brazing, welding, or compression.

33

(T) F **18.** Positive displacement is the moving of a fixed amount of a substance with each cycle of a hydraulic pump.

(T) F **19.** A spur gear has straight teeth parallel to the shaft axes.

Direct acting **20.** A(n) _____ valve is a valve that is activated or directly moved by a fluid pressure from the parallel port.

Sequence **21.** The _____ is the order in which a series of operations or movements are performed.

globe **22.** A(n) _____ valve is an infinite-position valve that has a disk that is raised or lowered over a port through which fluid flows.

dynamic **23.** A(n) _____ seal is used between moving parts to prevent leakage or contamination.

hydraulic **24.** A(n) _____ motor is a device that converts hydraulic energy into mechanical energy.

Ferrous **25.** _____ metals are metals containing iron.

Diagram Color Coding

E **1.** Red   **A.** Inactive fluid

C **2.** Yellow   **B.** Intermediate pressure that is lower than system operating pressure

B **3.** Orange   **C.** Controlled flow by a metering device or lowest working pressure

F **4.** Green   **D.** Exhaust or return flow to the reservoir

D **5.** Blue   **E.** Fluid flowing at system operating pressure or highest working pressure

A **6.** White   **F.** Intake flow to pump or drain line flow

Graphic Symbols – Lines

A **1.** Main line

C **2.** Pilot line

B **3.** Drain line

d **4.** Enclosure line

(A)   (B)   (C)   (D)
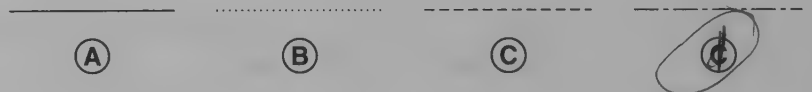
Linear Equivalents

A **1.** 1 in.

C **2.** .001 mm

B **3.** .0394 in.

D **4.** 1μ

(A)	25.4 mm	25,400μ
1 mm	(B)	1000μ
1μ	25,400 of an in.	(C)
(D)	3.94×10^{-5} in.	.000039 in.

Graphic Symbols – Squares or Rectangles

_____ *D*   *B*   **1.** Pressure switch

_____   **2.** Single-acting cylinder

_____ *C*   **3.** Double-acting cylinder

_____ *A*   **4.** Directional valve

_____ *E*   **5.** Pressure-relief valve
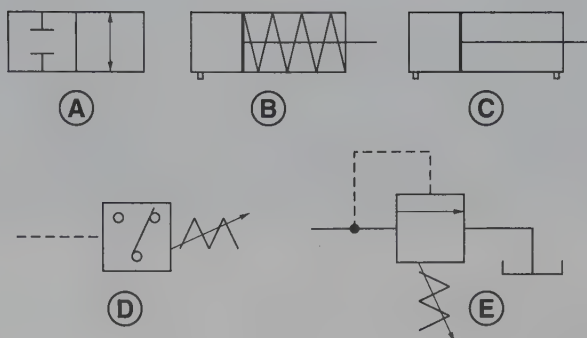
Gears

_____ *A*   **1.** Herringbone

_____ *C*   **2.** Helical

_____ *B*   **3.** Spur

TEETH
FORM HELIX
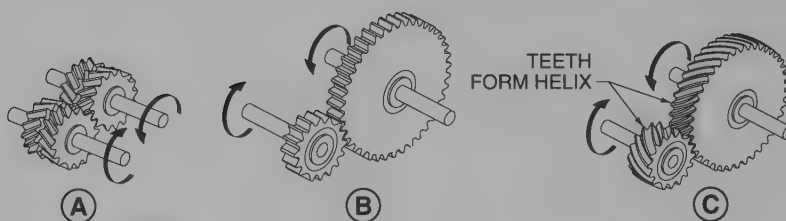
Pressure Gauge

_____ *I*   **1.** Scale

_____ *F*   **2.** Pivot

_____ *B*   **3.** Spring

_____ *H*   **4.** Pointer

_____ *G*   **5.** Siphon connection

_____ *J*   **6.** Pointer gear

_____ *A*   **7.** Bourdon tube

_____ *C*   **8.** Gear linkage

_____ *D*   **9.** Linkage arm

_____ *E*   **10.** Case
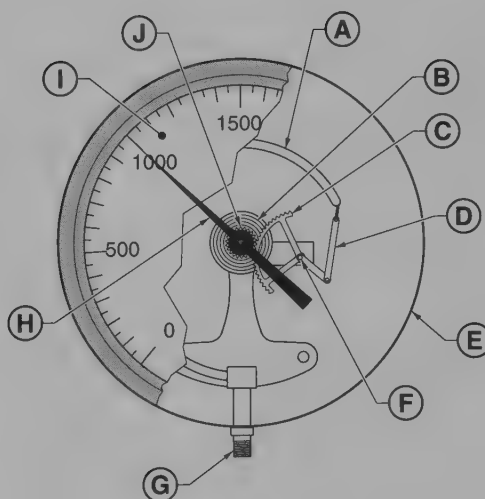
Check Valves

_B_
_A_
_C_

1. Poppet

2. Ball

3. Pilot-operated

PRESSURE OUT
A

P
PRESSURE IN

Ⓐ

A PRESSURE OUT

P
PRESSURE IN

Ⓑ

PRESSURE OUT A
P PRESSURE IN
T

Ⓒ
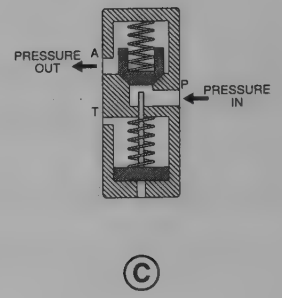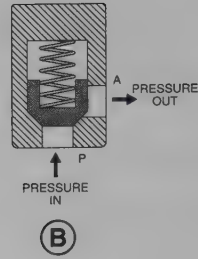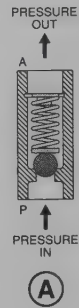
Problems

_1.5"_

1. The minimum bending radius of Tube A is _____ " R.

$\frac{1}{2}$" ID TUBE

?" R
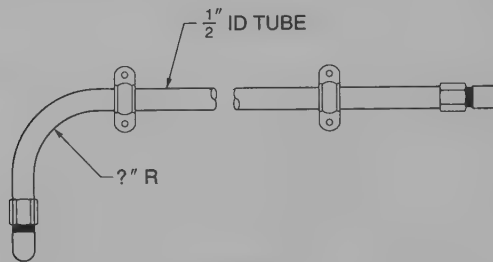
TUBE A

2. Add a single-acting spring-return cylinder to Circuit A.

FROM
PUMP
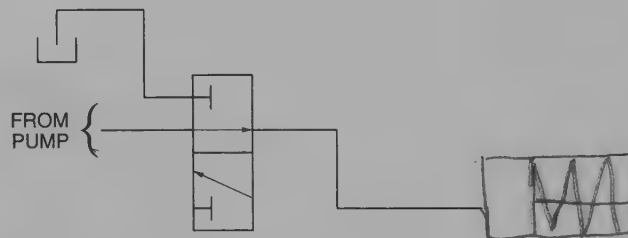
CIRCUIT A

3. Add a manually-actuated, spring-return, 3-way, two-position valve to control the cylinder in Circuit B.

Pump

A

Pressure
Relief
Value
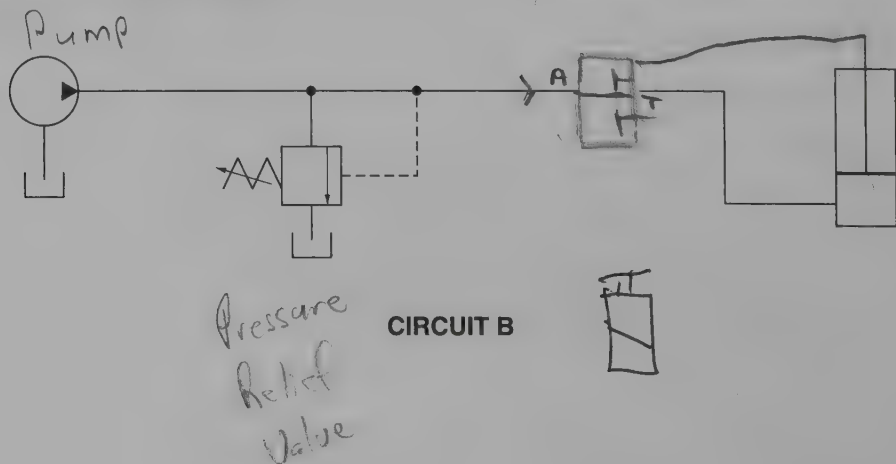
CIRCUIT B

Industrial Mechanics

_____   **1.** _____ is the branch of science that deals with the practical application of water or other liquids at rest or in motion.

_____   **2.** A(n) _____ is a closed path through which hydraulic fluid flows or may flow.

_____   **3.** A(n) _____ diagram uses drawings or pictures to show the relationship of each component in a circuit.

_____   **4.** A(n) _____ is a graphic element which indicates a particular device, etc.

_____   **5.** _____ is the temperature at which oil ignites by itself.
      A. Flash point   C. Auto-ignition
      B. Fire point   D. neither A, B, nor C

T   F   **6.** Strainer screens are rated in mesh and filters are rated in microns.

T   F   **7.** Pipe is designated according to its nominal size and wall thickness.

_____   **8.** A(n) _____ is a container for storing fluid in a hydraulic system.

_____   **9.** A(n) _____ is a mechanical device that causes fluid to flow.

_____   **10.** _____ is the process in which microscopic gas bubbles expand in a vacuum and suddenly implode when entering a pressurized area.

_____   **11.** A Bourdon tube is a hollow metal tube made of brass or similar material and is _____.
      A. elliptical in cross-sectional area   C. both A and B
      B. bent in a C-shape   D. neither A nor B

_____   **12.** _____ is the capability of a material to regain its original shape after being bent, stretched, or compressed.
      A. Plasticity   C. Resiliency
      B. Revertance   D. neither A, B, nor C

_____   **13.** A(n) _____ is a seal used between machined parts or around pipe joints to prevent the escape of fluids.

_____   **14.** _____ energy is the energy of motion.

_____   **15.** For graphic symbols used in hydraulic circuits, _____ that are completely shaded generally represent liquid flow.

_____ **16.** _____ are used in graphic diagrams to indicate an adjustable or variable component or to show shaft rotation on the near side of the shaft.
  A. Dashed lines   C. Dotted lines
  B. Solid lines   D. Arrows

_____ **17.** A _____ is a device containing a porous substance through which a fluid can pass but particulate matter cannot.
  A. funnel   C. filter
  B. strainer   D. mask

_____ **18.** A(n) _____ is a flexible tube for carrying fluids under pressure.

_____ **19.** The standard flare angle for hydraulic tube fittings is _____° from the centerline.

T   F   **20.** Tubes should always be assembled in a straight line.

T   F   **21.** A ferrule is a metal sleeve used for joining one piece of tube to another.

T   F   **22.** Vane pumps are the most widely used hydraulic pumps because of their simple design and ease of repair.

_____ **23.** A(n) _____ is a device that controls the pressure, direction, or rate of fluid flow.

_____ **24.** A hydraulic _____ is a device that converts hydraulic energy into mechanical energy.

_____ **25.** The container in which fluid is stored under pressure in a hydraulic system is the _____.

Graphic Symbols – Circles

_____ **1.** Pump

_____ **2.** Motor

_____ **3.** Pressure gauge

_____ **4.** Flow meter

_____ **5.** Check valve
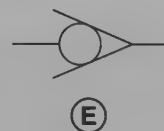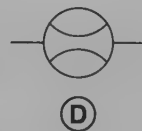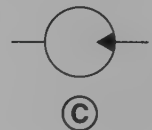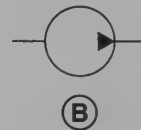
Graphic Symbols – Triangles

_____ **1.** Motor

_____ **2.** Air compressor

_____ **3.** Bidirectional motor

_____ **4.** Direction of flow
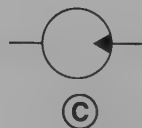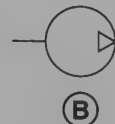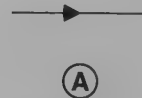
Flow Control Valves

_____ **1.** Factory preset orifice

_____ **2.** Globe

_____ **3.** Gate

_____ **4.** Needle

Ⓐ   Ⓑ   Ⓒ   Ⓓ
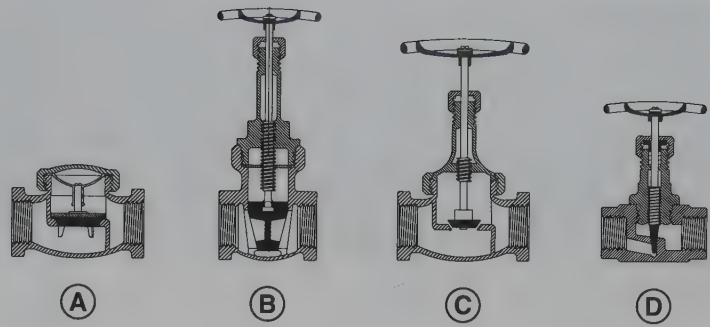
Filters

_____ **1.** Pressure

_____ **2.** Suction

_____ **3.** Return-line

Ⓐ   Ⓑ   Ⓒ
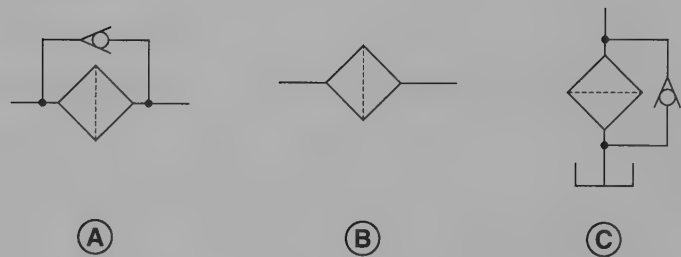
Single Actuators

_____ **1.** Manual

_____ **2.** Pushbutton

_____ **3.** Lever

_____ **4.** Foot pedal

_____ **5.** Solenoid

_____ **6.** Mechanical

_____ **7.** Detent

_____ **8.** Air pilot

_____ **9.** Spring

_____ **10.** Oil pilot

Ⓐ   Ⓑ   Ⓒ   Ⓓ

Ⓔ   Ⓕ   Ⓖ   Ⓗ

Ⓘ   Ⓙ
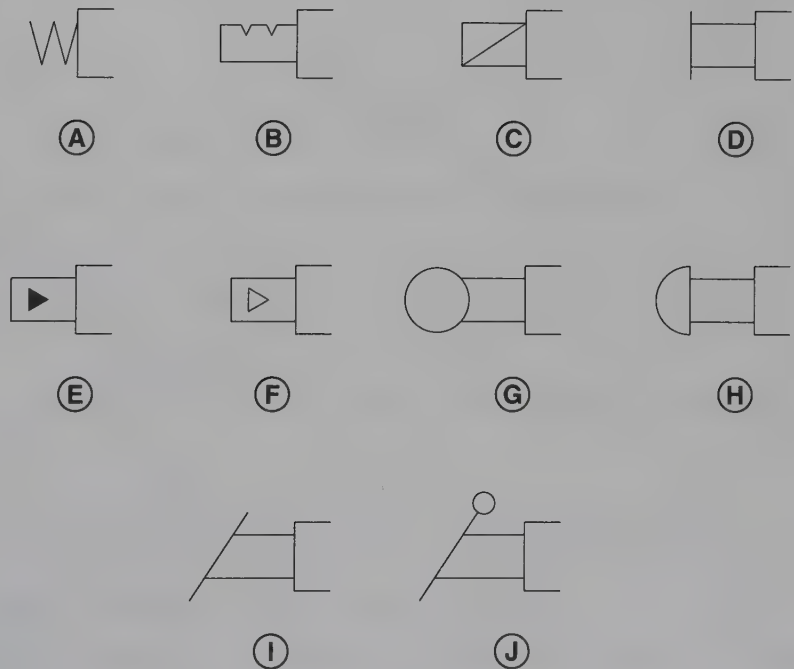
Problems

_____ **1.** The minimum bending radius of Hose A is _____ ″ R.

HOSE A
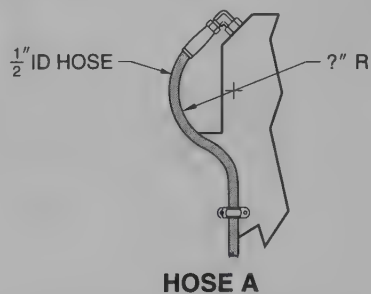
2. Add a pressure-relief valve to Circuit A.
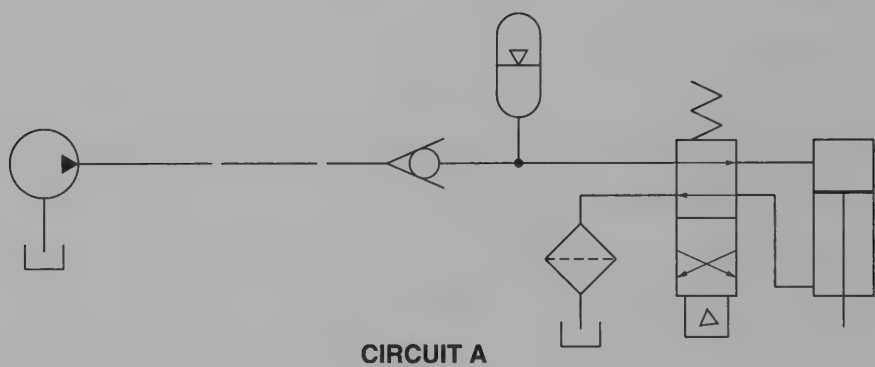
CIRCUIT A

3. Add a solenoid-operated, spring-return, 4-way, two-position directional control valve to control the fluid flow in Circuit B.

CIRCUIT B
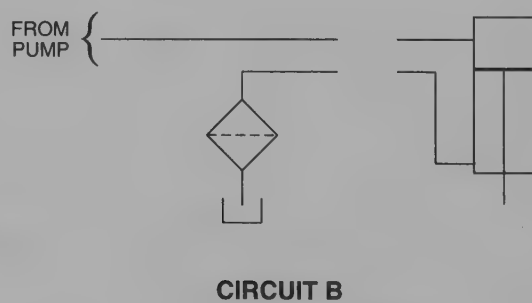
Pneumatic Principles

Chapter 7
Test 1

Name *Randy Stein* Date 10/24/2000

Industrial Mechanics

Pneumatics 1. _____ is the branch of science that deals with the transmission of energy using a gas.

Atom 2. A(n) _____ is the smallest building block of matter than cannot be divided into smaller units without changing its basic character.

Pressure 3. _____ is the force per unit area.

14.7 4. Atmospheric pressure at sea level is about _____ psi.

Volume 5. _____ is the three-dimensional size of an object measured in cubic units.

Absolute 6. _____ pressure is pressure above a perfect vacuum.

Vacuum 7. A(n) _____ is pressure lower than atmospheric pressure.

zero 8. Absolute _____ is the temperature at which substances possess no heat.

C 9. The temperature in °R is always _____° greater than the temperature in °F.
   A. 32   C. 460
   B. 212   D. 492

C 10. Free air is air at _____.
   A. atmospheric pressure ✓   C. both A and B
   B. ambient temperature   D. neither A nor B

Ⓣ F 11. Gas can expand to fill the volume and shape of its container.

Ⓣ F 12. Gas molecules can be pushed closer together, allowing gas to be compressed.

T Ⓕ 13. The pressure in a container varies as the size or shape of the container varies.

Gauge 14. _____ pressure is the pressure above atmospheric pressure that is used to express pressures inside a closed system.

reciprocating 15. A(n) _____ compressor is a device that compresses gas by means of a piston(s) that moves back and forth in a cylinder.

humidity 16. _____ is the amount of moisture in the air.

Particulate 17. A(n) _____ is a fine solid particle which remains individually dispersed in a gas.

Condensation 18. _____ is the change in state from a gas or vapor to a liquid.

? **instrumentation** 19. _____ is the area of industry that deals with the measurement, evaluation, and control of process variables.

_____ C _____ 20. Atoms combine to form _____.

  A. protons   C. molecules
  B. particles   D. neither A, B, nor C

_____ D _____ 21. The pressure exerted on Earth's surface varies with _____.

  A. altitude   C. humidity
  B. temperature   D. A, B, and C

T   **F**   22. In compression, air temperature decreases as a piston extends and the air molecules are forced closer together.

T   F   23. In an air compressor, multistage compression is required when the ratio of compression is greater than 6.

T   F   24. The total amount of moisture that air is capable of holding varies based on the temperature of the air.

Saturated 25. _____ air is air that holds as much moisture as it is capable of holding.

States of Matter

_____ A _____ **1.** Solid

_____ B _____ **2.** Liquid

_____ C _____ **3.** Gas
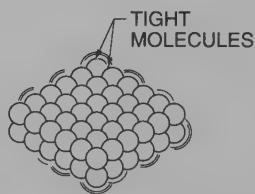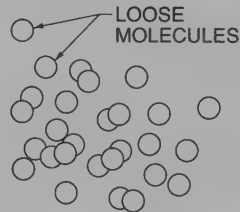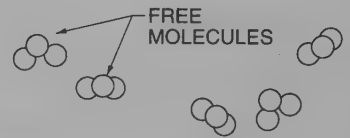
Gas Laws

_____ A _____ ✗ Boyle's law

_____ B _____ **2.** Charles' law

_____ A _____ **3.** Gay-Lussac's law
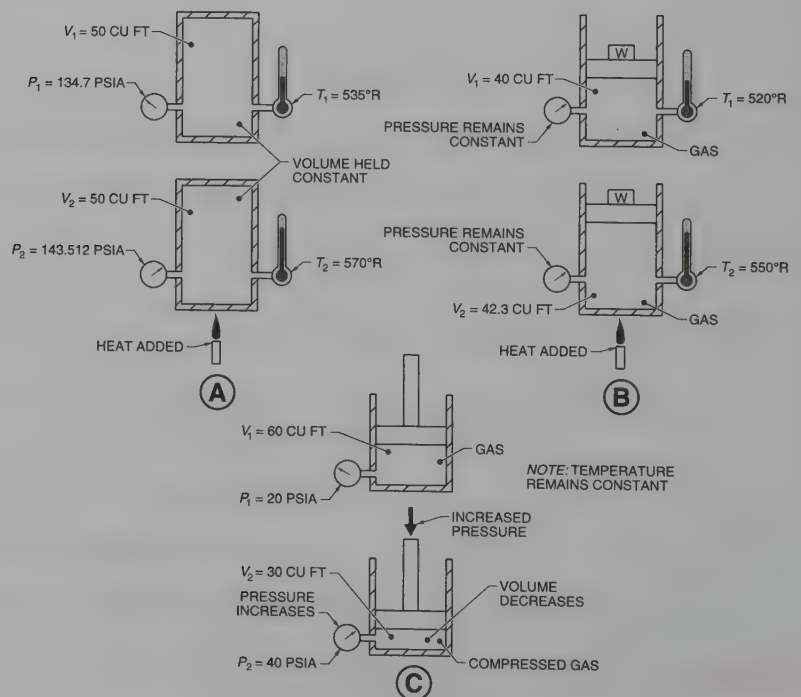
500 g

2.48

Desiccant Dryers

___B___   **1.** Check valves

___D___   **2.** Desiccant material

___E___   **3.** Reactivating dryer

___A___   **4.** Moist air inlet

___H___   **5.** Moist air outlet

___F___   **6.** Dryer operating

___C___   **7.** Purge valve

___G___   **8.** Dry air outlet
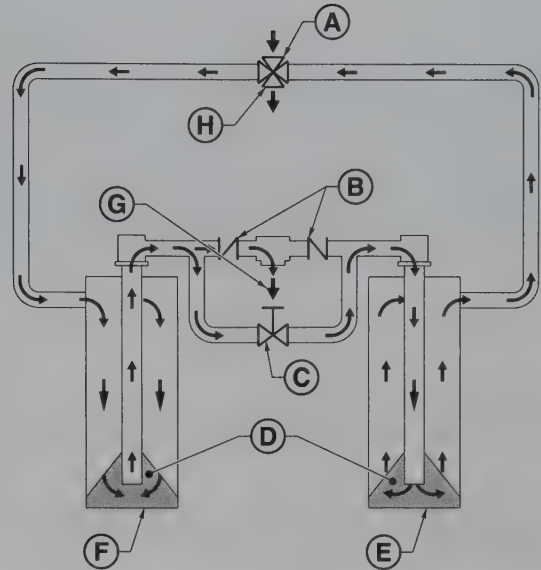
Fahrenheit/Rankine Temperatures

___E___   **1.** −460

___F___   **2.** 0

___C___   **3.** 32

___A___   **4.** 212

___D___   **5.** 492

___B___   **6.** 672

	°F	°R
WATER BOILS	(A)	(B)
WATER FREEZES	(C)	(D)
ABSOLUTE ZERO	(E)	(F)

Problems

___66.84___   **1.** Tank A has a volume of _____ cu ft.

___160.44___   **2.** Tank B has a capacity of _____ gal.

500 GAL. CAPACITY

1200 CU FT VOLUME

TANK A

TANK B

_90+74.7 = 109.7_ (handwritten top margin)

542° (handwritten answer)
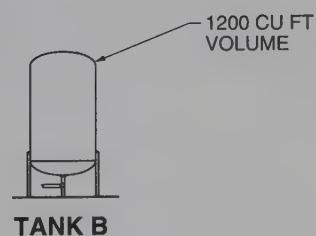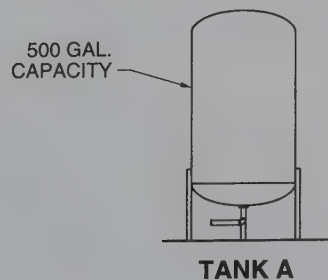
3. The temperature on the Fahrenheit scale equals _____ °R.

125.77 cu' (handwritten answer)

4. The final volume of a gas that occupies 120 cu ft at 60°F is _____ cu ft at 85°F.

Charles Law (handwritten)

111.94 (handwritten answer)

5. The final pressure in a 100 cu ft tank holding a gas at 90 psig at 75°F is _____ psig when the temperature is increased to 112°F.

_90_ (handwritten, near thermometer)
_460 / 542_ (handwritten)
_82°_ (thermometer label)
_460 / 572_ _46°_ (handwritten)

135 cu' (handwritten answer)

6. The final volume of 90 cu ft of air at 45 psia is _____ cu ft when compressed to 30 psia.

Boyles (handwritten) °F

4.81 (handwritten answer)

7. The ratio of compression is _____ in a compressor with an inlet pressure of 1.25 psi vacuum and a discharge pressure of 50 psig.

_14.7   13.45_
_-1.25_ (handwritten)
_14.7_
_C47_ (handwritten)

106.67 (handwritten answer)

8. The final pressure at Tank C is _____ psia.

416 CU IN. CAPACITY (label)
40 PSI (label)
COMPRESSED TO 156 CU IN. (label)

.47 (handwritten answer)

9. Cylinder A has a capacity of _____ gal.

.67 (handwritten answer)

10. Fuel Can A has a volume of _____ cu ft.

1.34 (handwritten answer)

11. Tub A has a volume of _____ cu ft.

TANK C

_40 × 416 / 156_ (handwritten)

CYLINDER A (3.5 CU FT)
FUEL CAN A (5 GAL.)
TUB A (10 GAL.)

42.7 (handwritten answer)
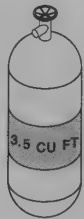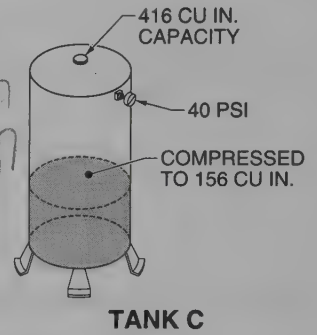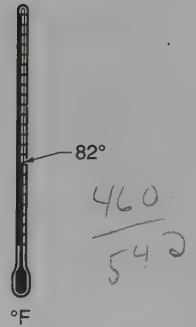
12. The absolute pressure within Tire A is _____ psia.
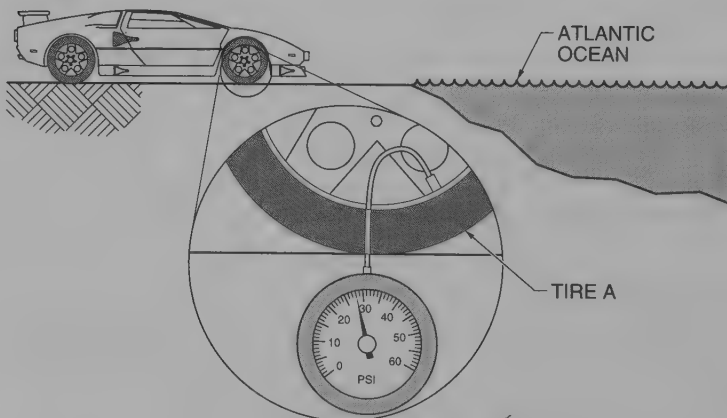
_5×90 / 30_ (handwritten margin)

ATLANTIC OCEAN

TIRE A

PSI
20 30 40
10   50
0   60

_120 × 545_
_595 520_ (handwritten)

_25 / 14.7_ (handwritten)

100

Industrial Mechanics

system **1.** A pneumatic _____ transmits and controls energy through the use of a pressurized gas within an enclosed circuit.

air

Compressor **2.** A(n) _____ is a device that takes air from the atmosphere and compresses it to increase its pressure.

reciporcating **3.** _____ pistons move forward and backward alternately.

Connecting **4.** A(n) _____ rod is the rod that connects the crankshaft to the piston.

lobe **5.** A(n) _____ is the screw helix of a rotor.
  A. tongue   C. leaf
  B. ear   D. lobe

_B_ **6.** The main header of a pneumatic system should have a downward pitch of _____ ' toward the drain pipe.
  A. 1″ per 1′   C. 10″ per 10′
  B. 1″ per 10′   D. neither A, B, nor C

(T) F **7.** A symbol is a graphic element which indicates a particular device, etc.

T (F) **8.** Thread-sealing material should be placed in the female fitting only.

(T) F **9.** The symbols for most of the components used in a pneumatic circuit are similar to those used in hydraulic circuits.

(T) F **10.** Logic is the science of correct reasoning.

_C_ **11.** A binary system has _C_ value(s).
  A. no   C. two
  B. one   D. any number of

_D_ **12.** A(n) _____ displacement compressor compresses a fixed quantity of air with each cycle.
  A. manual or automatic   C. vertical or horizontal tank
  B. electric or gasoline   D. neither A, B, nor C

Compensator **13.** A pressure _____ is a displacement control that alters displacement in response to pressure changes in a system.

One **14.** A check valve allows flow in only _____ direction(s).

Vane **15.** A(n) _____ compressor is a positive-displacement compressor that has multiple vanes located in an offset rotor.

___header___ **16.** A main _____ is the main air supply line that runs between the receiver and the circuits in a pneumatic system.

___filter___ **17.** A(n) _____ is a device containing a porous substance through which a fluid can pass but particulate matter cannot.

___10'___ **18.** Lubricators should be placed no more than _____' from the lubricated components.

___regulator___ **19.** A pressure _____ is a value that restricts and/or blocks downstream air flow.

___solenoid___ **20.** A(n) _____ is a device that converts electrical energy into a linear, mechanical force.

___A___ **21.** A(n) _____ is a device that senses a high- or low-pressure condition and relays an electrical signal to turn the compressor motor ON or OFF.
- A. pressure switch
- B. unloading valve
- C. safety release valve
- D. neither A, B, nor C

___B___ **22.** A(n) _____ is a device that senses a high-pressure condition and removes the compression energy.
- A. pressure switch
- B. unloading valve
- C. safety release valve
- D. neither A, B, nor C

___C___ **23.** A(n) _____ is a device that prevents excessive pressure from building up by venting air to the atmosphere.
- A. pressure switch
- B. unloading valve
- C. safety release valve
- D. neither A, B, nor C

(T) F **24.** An O-ring may be used as a static or a dynamic seal.

T (F) **25.** An air motor is an air-driven device that converts rotary mechanical energy into fluid energy.

(T) F **26.** A truth table lists the output condition of a logic element or combination of logic elements for every possible input condition.

T (F) **27.** Electric motors are less efficient than air motors.

(T) F **28.** Air motors are lighter than direct replacement electric motors.

(T) F **29.** The most popular air motor is the vane air motor.

(T) F **30.** Pneumatic circuits are generally cleaner than hydraulic circuits.

___Circuit___ **31.** A pneumatic _____ is a combination of air-operated components that are connected to perform work.

___position___ **32.** A(n) _____ is the specific location of a spool within a valve which determines the direction of fluid flow through the valve.

___cylinder___ **33.** An air _____ is a device that converts compressed air energy into linear mechanical energy.

___static___ **34.** A(n) _____ seal is a seal used as a gasket to seal nonmoving parts.

___dynamic___ **35.** A(n) _____ seal is a seal used between moving parts that prevents leakage or contamination.

Graphic Diagram – Pneumatic System

____F____ **1.** Motor

____G____ **2.** Filter

____I____ **3.** Aftercooler

____D____ **4.** Separator

____A____ **5.** Pressure switch

____E____ **6.** Compressor

____B____ **7.** Receiver

____H____ **8.** Safety relief valve

____C____ **9.** Manual shut-off valve
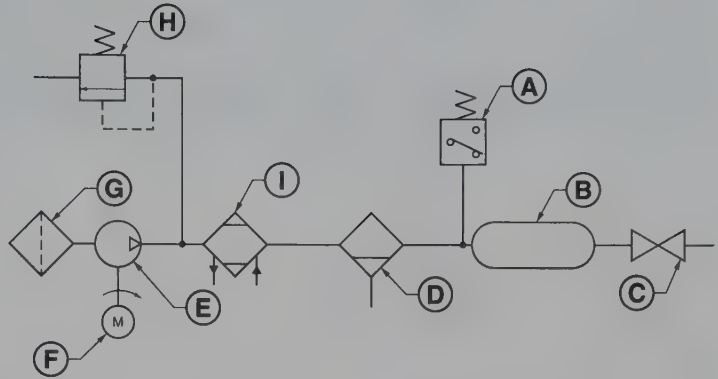
Graphic Diagram – Pneumatic Circuit

____D____ **1.** Compressor

____A____ **2.** Actuator

____C____ **3.** Regulator

____F____ **4.** Lubricator

____E____ **5.** Filter

____B____ **6.** Directional control valve
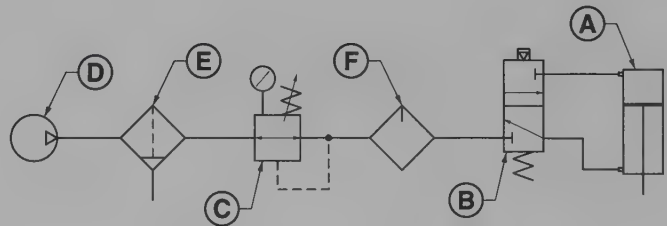
Safety Relief Valves

____B____ **1.** Spring

____D____ **2.** System pressure

____G____ **3.** Valve vent port

____C____ **4.** Seat

____E____ **5.** Poppet

____A____ **6.** Pull ring

____F____ **7.** Vent to atmosphere
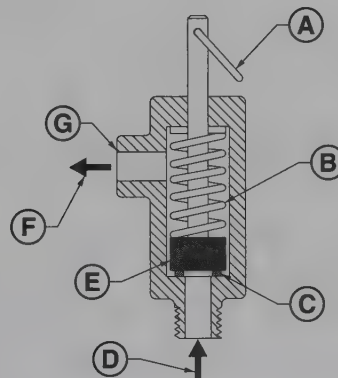
Pneumatic System Symbols

___D___ **1.** Pipe slope in direction of flow

___F___ **2.** Liquid separator with automatic drain

___E___ **3.** Filter with manual drain

___G___ **4.** Lubricator with manual drain

___A___ **5.** Gate valve

___B___ **6.** Automatic drain ?

___C___ **7.** Quick disconnect

Ⓐ ✓   Ⓑ   Ⓒ ✓   Ⓓ ✓

Ⓔ ✓   Ⓕ ✓   Ⓖ ✓
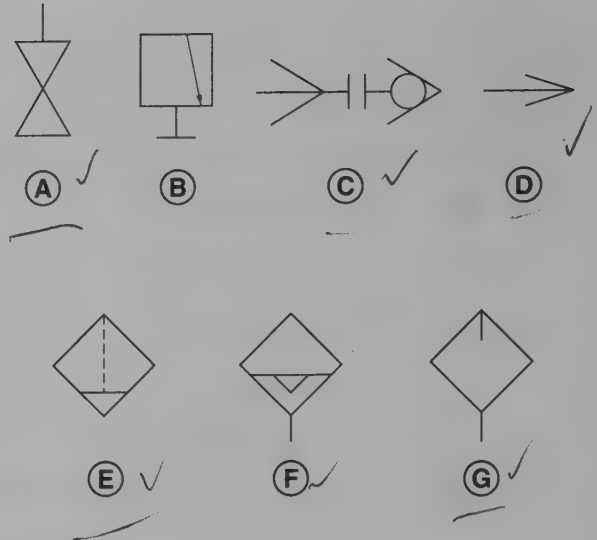
Problems

1. The outlet pressure produced by the intensifier is __1,333.45__ psi.

$$\frac{19.635 \times 120}{1.767}$$

OPERATING PISTON AREA = 19.635 SQ. IN.
RAM AREA = 1.767 SQ. IN.
INLET PRESSURE = 120 PSI

? PSI

INTENSIFIER

2. The main header should drop __3.4__ " from the receiver to the moisture drop pipe.

MAIN HEADER

CIRCUIT BRANCH LINE

34' TO RECEIVER

MOISTURE DROP PIPE

DRAIN VALVE

Lubrication

Name _Randy Stein_   Date
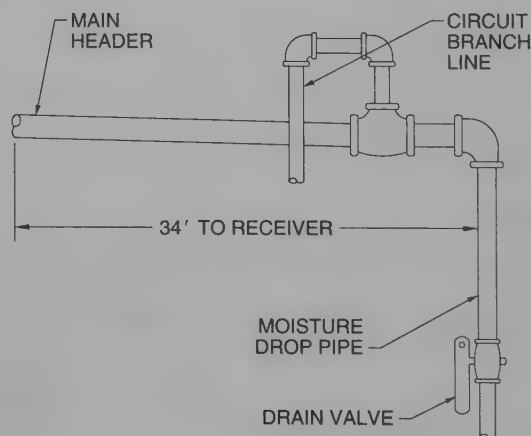
Chapter 9
Test 1

Industrial Mechanics

Lubrication **1.** _____ is the process of maintaining a fluid film between solid surfaces to prevent their physical contact.

Coefficient **2.** The _____ of friction is the measure of frictional force between two surfaces in contact.

Chemisorption **3.** _____ is a chemical adsorption process in which weak chemical bonds are formed between liquid or gas molecules and solid surfaces.

inert **4.** _____ gases are gases that lack active properties.

(T) F **5.** Walking requires friction between the feet and floor in order to move.

T (F) **6.** Lubrication generally involves coating surfaces with a material that has a higher coefficient of friction than the original surfaces.

(T) F **7.** Friction occurs when an object in contact with another object tries to move.

_D_ **8.** Lubricants are used to _____.
- A. reduce friction
- B. prevent wear
- C. prevent corrosion
- D. A, B, and C

_D_ **9.** Liquid lubricants include _____.
- A. animal/vegetable oils
- B. petroleum fluids
- C. synthetic fluids
- D. A, B, and C

(T) F **10.** Animal and vegetable oils are used mostly in the food industry.

(T) (F) **11.** Petroleum is composed of 12% carbon and 85% hydrogen, with a small amount of other elements.

(T) F **12.** Animal and vegetable oils contain fatty acids.

_175_ **13.** Earth's plants release approximately _____ million tons of hydrocarbons into the air each year.

Viscosity **14.** _____ is the measurement of the resistance of a fluid's molecules to move past each other.

Strength **15.** Shear _____ is a liquid's ability to remain as a separator between solids in motion.

spectrometer **16.** A(n) _____ is a device that vaporizes elements in the oil sample into light.

(T) F **17.** The grease used in a centralized system should be one grade softer than is otherwise required.

T (F) **18.** Sealed bearings should be relubricated on a regularly-scheduled basis.

T ~~(F)~~ **19.** Shear stress is stress in which the material on one side of a surface pushes on the material on the other side of the surface with a force perpendicular to the surface.

~~(T)~~ F **20.** Synthetic lubricants are generally higher priced than petroleum lubricants.

___C___ **21.** During startup of a machine, oil _____.
  A. is cool
  B. does not flow easily
  C. A and B
  D. neither A nor B

___C___ **22.** _____ action is the action by which the surface of a liquid is elevated on a material due to its relative molecular attraction.
  A. Submission
  B. Polymeric
  C. Capillary
  D. neither A, B, nor C

~~(T)~~ F **23.** Lubrication contamination is the main cause of mechanical system failure.

T ~~(F)~~ **24.** Oil that is contaminated with water has a clear appearance.

~~(T)~~ F **25.** Petroleum is formed by an evolutionary process that takes many millions of years.

Lubricant Additives

___E___ **1.** Oxidation inhibitors
___A___ **2.** Rust inhibitors
___B___ **3.** Fatty materials
___C___ **4.** Powdered lead or graphite
___F___ **5.** Viscosity index improvers
___D___ **6.** Demulsifiers

A. prevent rust ✓
B. improve film strength
C. prevent galling
D. separate out water ✓
E. provide long bearing or gear life
F. ease machine movement in cold weather

Oil Groups/Application

___B___ **1.** Group A
___E___ **2.** Group B
___A___ **3.** Group C
___F___ **4.** Group D
___D___ **5.** Group E
___C___ **6.** Group F

A. Machine tools
B. Automotive
C. Reciprocating engines
D. Turbojet engines
E. Gear trains and transmissions
F. Marine propulsions and stationary power turbines

Oil Application Systems

_C_	**1.** Submersion – Splash
_B_	**2.** Submersion – Chain
_A_	**3.** Submersion – Ring
_E_	**4.** Drip
_D_	**5.** Wick
_F_	**6.** Centralized

LEVEL — LOWEST BALL — BEARING IMMERSED HALFWAY UP LOWEST BALL

RING — SHAFT

A

LEVEL — TWICE TOOTH HEIGHT — GEARS IMMERSED TO TWICE TOOTH HEIGHT

CHAIN — GEAR

B

SLINGER

C

WICK (PIPE CLEANER) — BEARING — CUP — FELT PAD

D

CUP — SIGHT GLASS — DRIP FEED — NEEDLE VALVE — BEARING

E

RESERVOIR — TIMED PUMP WITH ADJUSTABLE FEED — PLUMBING — DISTRIBUTION VALVES
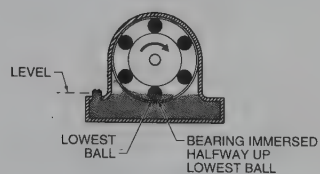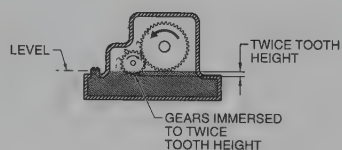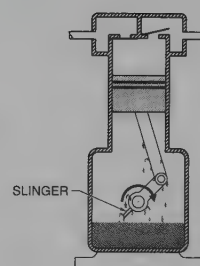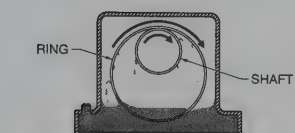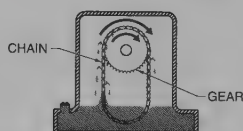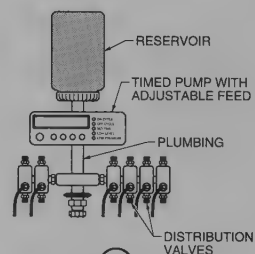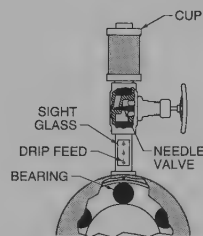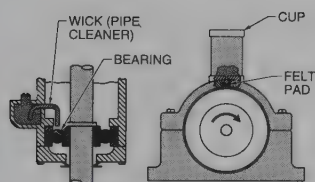
F

Grease Thickeners

_C_	**1.** Aluminum soap	**A.** Used for extreme temperatures
_D_	**2.** Calcium soap	**B.** Added to resist being thrown off
_E_ _B_	**3.** Lithium soap	**C.** Offers clarity
_A_	**4.** Clay	**D.** Is water-resistant
_B_	**5.** Fiber	**E.** Allows high temperature use

Problems

.333

1. The coefficient of friction of Object A is _____.

$\dfrac{10}{30} = -$

OBJECT A

10 LB   30 LB
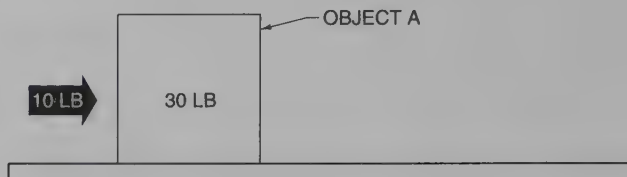
$\dfrac{40}{75} =$ .533

2. A 40 lb force is required to overcome the frictional force between a 75 lb object and the surface upon which it is resting. The coefficient of friction is _____.

T   Ⓕ

3. The coefficient of friction of Object B is 5.

$\dfrac{8}{40} =$

OBJECT B

8 LB   40 LB
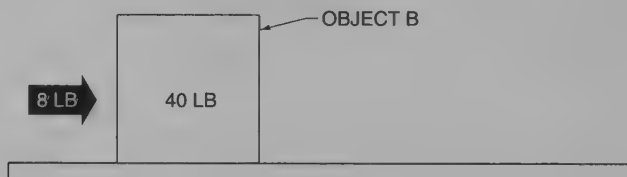
Lubrication

Name _____   Date _____

Industrial Mechanics

T   F   **1.** Greater force is required to move a body from a static condition than is required to keep it in a kinetic condition.

_____   **2.** _____ lubrication is the condition of lubrication in which the friction between two surfaces in motion is determined by the properties of the surfaces and the properties of the lubricant other than viscosity.
    A. Area   C. Surface
    B. Material   D. neither A, B, nor C

_____   **3.** A(n) _____ lubricant is a lubricant that uses pressurized air to separate two surfaces.
    A. chemical   C. gas
    B. metal   D. neither A, B, nor C

_____   **4.** A petroleum fluid is a fluid consisting of _____.

T   F   **5.** The flow rate is the most important property of a lubricant.

T   F   **6.** Under basic conditions, as the temperature of oils increases, their viscosity also increases.

T   F   **7.** Lubricating oil is given an SAE viscosity rating based on its ability to flow at a specific temperature.

T   F   **8.** A 10 weight oil is thicker than a 40 weight oil.

_____   **9.** A _____ solid is a solid that is finely ground in order to be spread.
    A. disposed   C. dispelled
    B. dispersed   D. displaced

_____   **10.** A _____ is the result of a chemical reaction in which two or more small molecules combine to form larger molecules.
    A. polygon   C. either A or B
    B. polymer   D. neither A nor B

T   F   **11.** Solid lubricants such as graphite shear easily between sliding surfaces.

T   F   **12.** All greases exhibit a dropping point.

T   F   **13.** Water that mixes with lubricants increases the effectiveness of the lubricant.

_____   **14.** Wear particle _____ is the study of wear particles present in lubricating oil.

_____   **15.** Fluid lubricants must create a(n) _____ between material surfaces to prevent contact with each other.

T   F   **16.** As temperatures increase, greases become softer.

T   F   **17.** Graphite has high shearing forces.

T   F   **18.** Gas lubricants are commonly used in low-friction, high-speed applications.

_____   **19.** Approximately _____% of all lubricants used today are petroleum based.

_____   **20.** Oil film thickness _____ with an increase in oil temperature.

Petroleum

_____   **1.** Pilot oil well

_____   **2.** Crude oil pumped from well

_____   **3.** Soil

_____   **4.** Porous rock

_____   **5.** Nonporous rock

_____   **6.** Bedrock

_____   **7.** Crude oil

_____   **8.** Natural gas
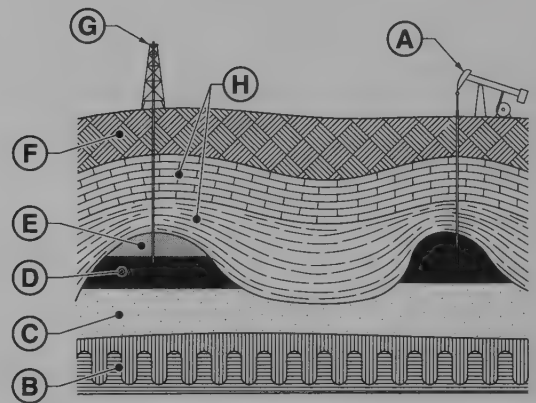
Motor Regreasing

_____   **1.** Wipe grease fitting, drain plug, and grease gun nozzle.

_____   **2.** Remove drain plug and clean.

_____   **3.** Add grease until grease is expelled from drain plug port.

_____   **4.** Run motor to expel excess grease.

_____   **5.** Clean and replace drain plug.
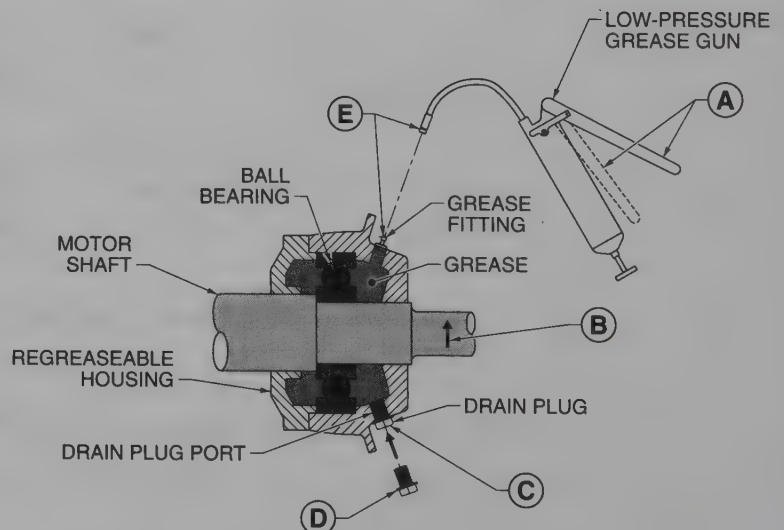
Grease Application Methods

_____ **1.** Grease cup

_____ **2.** Grease gun

_____ **3.** Centralized system

HANDLE — GREASE — SPRING

PRESSURE-APPLYING SCREW CAP — GREASE

PLUMBING — AIR IN → GREASE OUT — RESERVOIR — PRESSURE — DIAPHRAGM — GREASE

Ⓐ   Ⓑ   Ⓒ
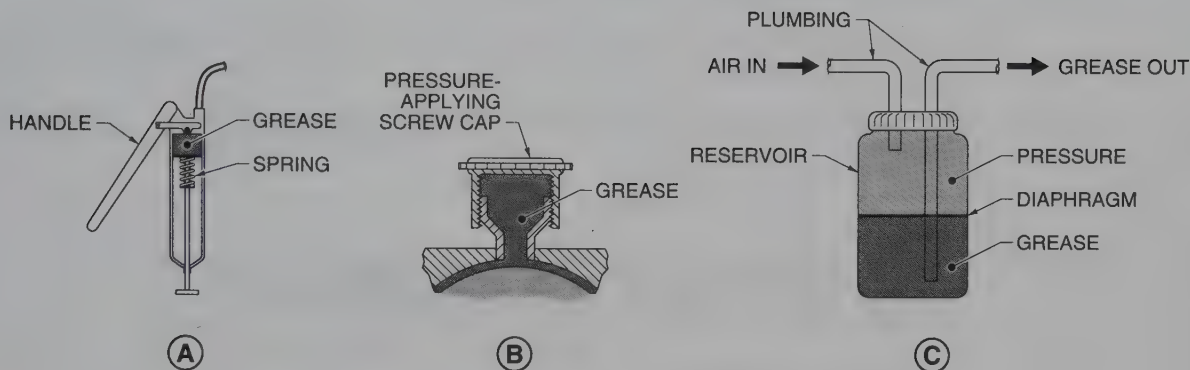
NLGI Grease Grades

T   F   **1.** The higher the NLGI number, the stiffer the grease.

T   F   **2.** The higher the NLGI number, the more penetration it has.

T   F   **3.** Grade 1 is softer than Grade 00.

_____ **4.** Grade 5 will penetrate approximately one-half as much as Grade _____.

T   F   **5.** Grade 000 has three times the penetration of Grade 0.

T   F   **6.** Grades 0, 1, and 2 are the most widely used in industry.

T   F   **7.** For maximum penetration, a higher NLGI grade of grease should be used.

_____ **8.** NLGI Grade _____ has a penetration range from .68″ to .80″.

NLGI GREASE GRADES		
NLGI Grade	**Penetration***	**Stiffness**
000	1.75 – 1.87	VERY SOFT
00	1.57 – 1.69	
0	1.32 – 2.30	
1	1.22 – 1.33	
2	1.04 – 1.16	
3	.86 – .98	
4	.68 – .80	
5	.51 – .62	
6	.33 – .45	VERY HARD

* in in.

Coefficients of Friction

T   F   **1.** Greater force is required to move a body from rest than is required to keep it in motion.

T   F   **2.** The static condition relating to coefficient of friction refers to the forces required to start a solid object in motion.

_____   **3.** The coefficient of friction required to start the movement of a piece of copper resting on an unlubricated copper plate is _____.

_____   **4.** The coefficient of friction required to maintain the movement of a piece of copper on an unlubricated copper plate is _____.

_____   **5.** A steel object resting on an unlubricated piece of steel weighs 10 lb. A force of _____ lb is required to start it in motion.

COEFFICIENTS OF FRICTION				
Material	**Unlubricated**		**Lubricated***	
	Static	**Kinetic**	**Static**	**Kinetic**
Steel-to-Steel	.8	.4	.16	.02
Copper-to-Copper	1.5	.3	.08	.02
Aluminum-to-Aluminum	1.3	—	.3	—
Nylon-to-Nylon	.3	.1	—	—
Teflon-to-Teflon	.04	.03	—	—
Graphite-to-Graphite	.1	.06	—	—

* values are approximations and vary according to lubricant type

Bearings

Chapter 10 Test 1

Name _____ Date _____

Industrial Mechanics

bearing   **1.** A(n) _____ is a machine part that supports another part, such as a shaft, which rotates or slides in or on it.

Fatigue   **2.** _____ life is the maximum useful life of a bearing.

Axial   **3.** A(n) _____ load is a load in which the applied force is parallel to the axis of rotation.

Service   **4.** _____ life is the length of service received from a bearing.

C   **5.** The _____ is the track on which the balls of a bearing move.
     A. cup   C. race
     B. cone   D. neither A, B, nor C

A   **6.** Under normal load conditions, ball bearings generally have _____ ″ interference per inch of shaft when the inner race is press fit.
     A. .00025   C. .025
     B. .0025   D. .25

T   (F)   **7.** Doubling the load on a bearing increases its service life by 6 to 8 times.

(T)   F   **8.** A better finish on a bearing produces less friction.

(T)   F   **9.** Ball bearings are installed with one ring being a press fit and the other ring a push fit.

(T)   F   **10.** Needle bearings are generally press fit.

Plain   **11.** A(n) _____ bearing is a bearing in which the shaft turns and is lubricated by a sleeve.

Spalling   **12.** _____ is the flaking away of metal pieces due to metal fatigue.

dropping point   **13.** The _____ of grease is the temperature at which the oil in grease separates from the thickener and runs out, leaving just the thickener.

misaligned   **14.** Bearing surfaces that are _____ appear as worn surfaces on one side or opposing sides of a bearing.

galling   **15.** _____ is a bonding, shearing, and tearing away of material from two contacting, sliding metals.

Thrust   **16.** _____ damage is bearing damage due to axial force.

Fluttung   **17.** _____ is the elongated and rounded grooves or tracks left by the etching of each roller on the rings of an improperly grounded roller during welding.

runout   **18.** Precision class bearings are generally marked with their high points of _____.

end   **19.** _____ play is the total amount of axial movement of a shaft.

rolling   **20.** A _____-contact bearing is a bearing composed of rolling elements between an inner and outer ring.

(T)   F   **21.** Plain bearings may support radial and axial loads.

(T)   F   **22.** Bearing installation is generally more difficult than bearing removal.

(T)   F   **23.** Bearings should never be struck with a hammer.

(T)   F   **24.** Solid or caked lubricant is a sign that bearings have overheated.

(T)   F   **25.** As the temperature of steel increases, it discolors, turning from silver to blue to black.

T   (F)   **26.** Prelubricated bearings may be heated for installation.

(T)   F   **27.** Never apply pressure on the outer ring if the inner ring is press fit and never apply pressure on the inner ring if the outer ring is press fit.

follower   **28.** A threaded cup _____ is a tapered bearing gap adjusting device that is used to adjust shaft endplay by controlling the amount of clearance between tapered roller bearings.

tapered   **29.** A(n) _____ bore bearing is a bearing whose bore varies in diameter from the face to the back of the bearing.

T   (F)   **30.** Roller-contact bearings include ball, roller, and needle bearings.

T   (F)   **31.** Needle bearings are designed primarily for relatively low radial loads.

(T)   F   **32.** Babbitt metals are the best metals for light plain bearing loads.

(T)   F   **33.** False Brinell damage is bearing damage caused by forces passing from one ring to the other through the balls or rollers.

(T)   F   **34.** A machine should never be grounded by connecting a wire from the machine to a gas or oil pipe.

journal   **35.** A(n) _____ is the part of a shaft, such as an axle or spindle, that moves in a plain bearing.

Bearing Failure

_B_   **1.** Dark, discolored metals indicate _____.   **A.** improper fit or assembly

_C_   **2.** Rusting surfaces indicate _____.   **B.** high temperatures

_A_   **3.** Split or fractured rings indicate _____.   **C.** high moisture and/or improper

Angular Contact Bearing Use

_____ B _____

_____ A _____

_____ C _____

1. Face-to-face

2. Back-to-back

3. Separated face-to-face

LINES OF FORCE

(A)   (B)

LINE OF FORCE
FACE-TO-FACE
SHAFT

(C)
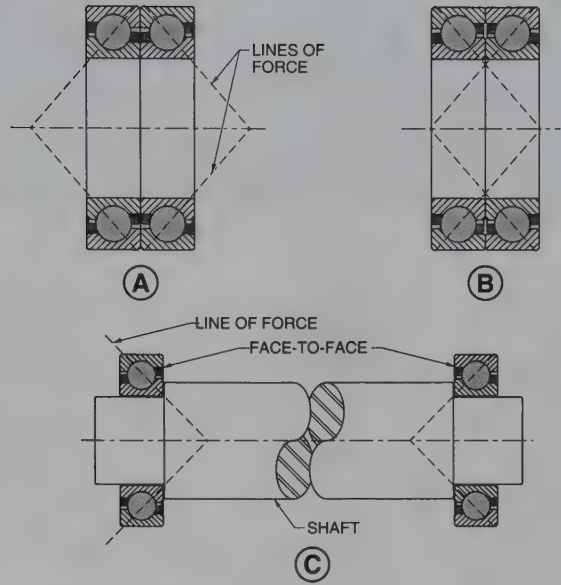
Bearing Loads

_____ A _____

_____ B _____

1. Radial load

2. Axial load

BEARING SURFACE
SHAFT
BEARING SURFACE
APPLIED FORCE PERPENDICULAR TO AXIS OF ROTATION
SHAFT ROTATION
AXIS OF ROTATION

(A)

SHAFT ROTATION
AXIS OF ROTATION
SHAFT
BEARING SURFACE
APPLIED FORCE PARALLEL TO AXIS OF ROTATION
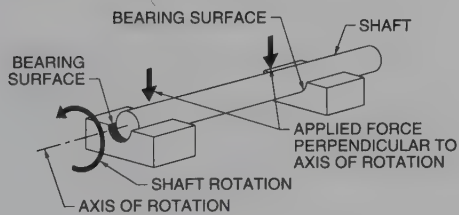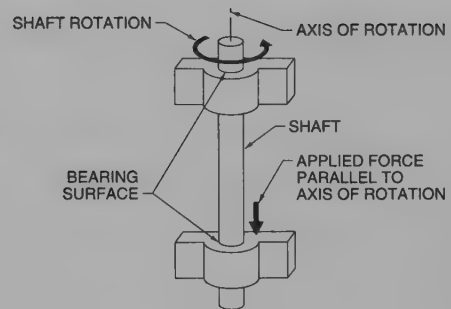
(B)

Rolling-Contact Bearings

_____ A _____

_____ C _____

_____ B _____

1. Ball

2. Needle

3. Roller
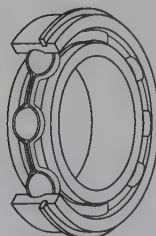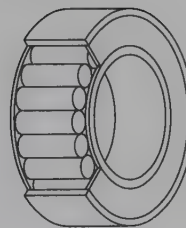
(A)   (B)   (C)

Ball Bearings

_____ A   1. Single-row radial

_____ B   2. Single-row angular-contact

_____ C   3. Double-row radial or axial

Ⓐ   Ⓑ   Ⓒ

Flexible Belt Drives

Chapter 11
Test 1

Name _____   Date _____

Industrial Mechanics

V belt **1.** A(n) _____ is an endless power transmission belt with a trapezoidal cross section.

Standard **2.** _____ V-belts are designated as A, B, C, D, or E.

High Capcity **3.** _____ V-belts are designated as 3V, 5V, or 8V.

pulley **4.** V-belts run in a(n) _____ (sheave) with a V-shaped groove.

1/2° **5.** Angular misalignment of a pulley must not exceed _____°.

(T) F **6.** Too little tension on a belt can cause the belt to slip.
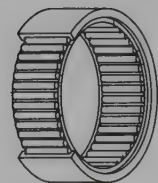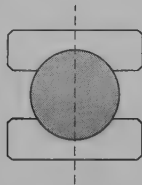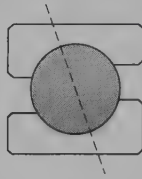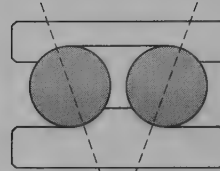
Lockout **7.** _____ is the process of preventing the flow of energy from a power source to a piece of equipment.

Tagout **8.** _____ is the process of placing a tag on a power source that warns others not to restore *TAG* energy.

blockout **9.** _____ is the process of placing a solid object in the path of a power source to prevent accidental energy flow.

T (F) **10.** For optimum efficiency, a V-belt should touch the bottom of the pulley.

T (F) **11.** V-belt forces remain constant as the belt bends around the pulley.

(T) F **12.** A fixed bore pulley is a machine-bored one-piece pulley.

(T) F **13.** Pulleys should be placed as close as possible to the shaft bearing to prevent overhung loads.

___A___ **14.** _____ misalignment is a condition where two shafts are parallel but the pulleys are not on the same axis.
    A. Offset   C. Angular
    B. Non-parallel   D. neither A, B, nor C

___D___ **15.** A _____ V-belt is a belt designed to transmit power from the top and bottom of the belt.
    A. ½   C. single
    B. top/bottom   D. double

Variable Speed **16.** A(n) _____ belt drive is a mechanism that transmits motion from one shaft to another and allows the speed of the shafts to be varied.

Belt + Sheave **17.** A(n) _____ groove gauge is a gauge that has a male form to determine the size of a pulley and a female form to determine the size of a belt.

61

Timing 18. A(n) _____ belt is a belt designed for positive transmission and synchronization between the drive shaft and the driven shaft.

Pitch 19. Belt _____ length is the total length of the timing belt measured at the belt pitch line.

nominal 20. A(n) _____ value is a designated or theoretical value that may vary from the actual value.

Timing Belt Tooth Profiles

D ~~1.~~ Trapezoidal

B **2.** Double trapezoidal

C **3.** Curvilinear

A ~~4.~~ Modified curvilinear

Variable-Speed Belt Drives

LOW **1.** The variable-speed belt drive is at _____ speed.

B **2.** Spring

D **3.** Shaft

G **4.** V-belt

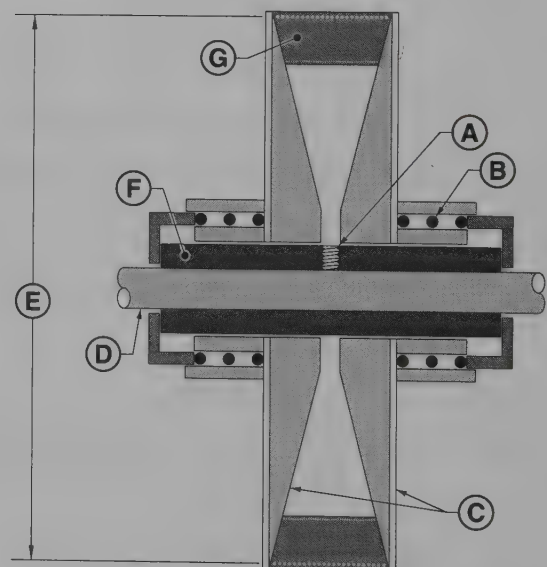**E** **5.** Pitch diameter

F **6.** Central sheave

C **7.** Cone-faced pulley flanges

A **8.** Set screw

Recommended Minimum Pulley Diameters

_3.8 in._ **1.** The recommended minimum pulley diameter for a 7½ HP motor running at 1160 rpm is _____".

_4.4 in._ **2.** The recommended minimum pulley diameter for a 15 HP motor running at 1750 rpm is _____".

_2.2 in._ **3.** The recommended minimum pulley diameter for a 1 HP motor running at 1750 rpm is _____".

_12 in._ **4.** The recommended minimum pulley diameter for a 100 HP motor running at 870 rpm is _____".

Motor HP	Motor Speed**			
	870	1160	1750	3500
½	2.2	—	—	—
¾	2.4	2.2	—	—
1	2.4	2.4	2.2	—
1½	2.4	2.4	2.4	2.2
2	3.0	2.4	2.4	2.4
3	3.0	3.0	2.4	2.4
5	3.8	3.0	3.0	2.4
7½	4.4	3.8	3.0	3.0
10	4.4	4.4	3.8	3.0
15	5.2	4.4	4.4	3.8
30	6.8	6.8	5.2	—
75	10.0	10.0	8.6	—
100	12.0	10.0	8.6	—

RECOMMENDED MINIMUM PULLEY DIAMETERS*

* in in.
** in rpm

Pulley Misalignment

_C_ **1.** Angular

_A_ **2.** Offset

_B_ **3.** Nonparallel

$2 \times 42 + 1.57 \times (10+6) + \frac{10-6^2}{4 \times 42}$

$84 + 1.57 \times 16 + \frac{16}{168}$
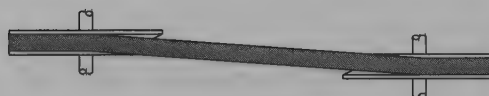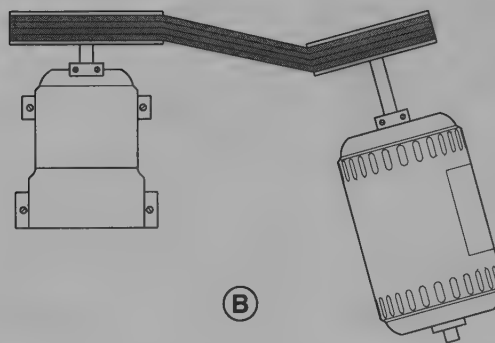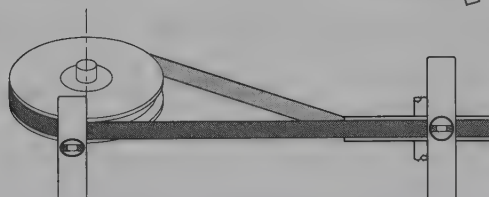
$84 + 1.57 \times 16 + 4^2 \times$

$\frac{84 + 1.57 \times 16 + 16}{168}$

Problems $84 + 1.57 \times 16 + .095238$

109.21

1. The belt length for two pulleys 6″ and 10″ in diameter that are 42″ apart at their centers is _____″.

__89.44__   **2.** The belt length required at A is _____″.

__.75__   **3.** The proper belt deflection at B is _____″.

__275.5__   **4.** The driven pulley speed at C is _____ rpm.

__360__   **5.** The drive pulley speed at D is _____ rpm.

A

B

C

D

$B \quad 48'' \times \frac{1}{64}$

$C \quad \frac{3.8'' \times 870}{12''} = 275.5$

D
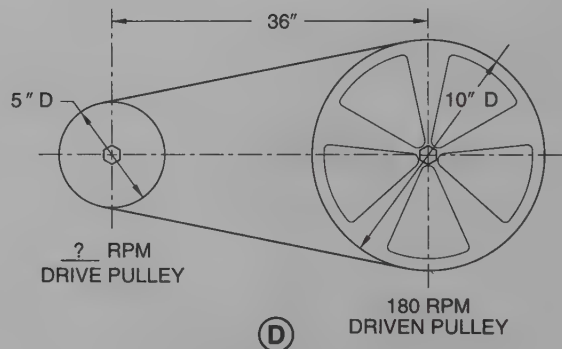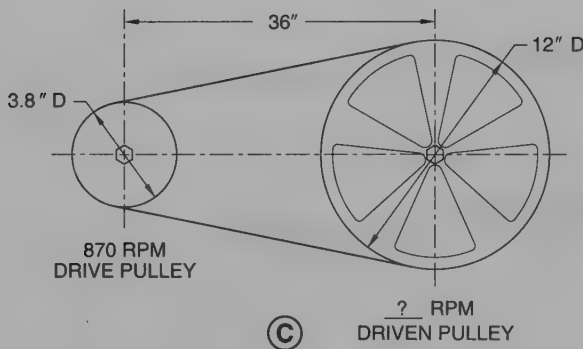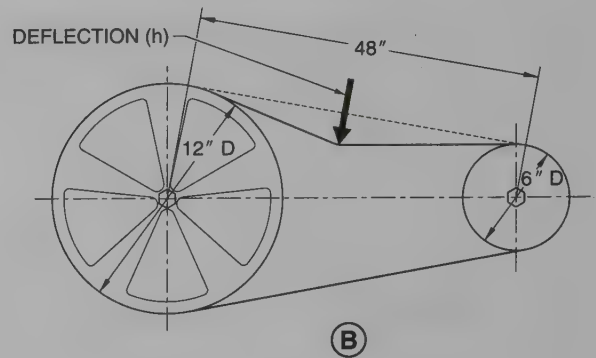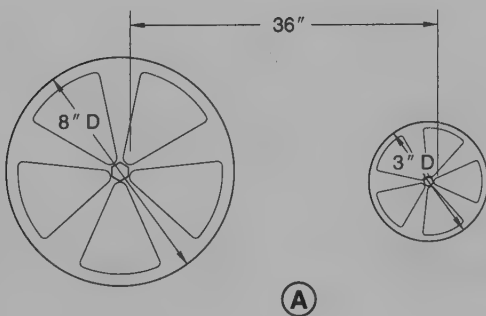
$\frac{10 \times 180}{5} = 360$

Mechanical Drives

Chapter 12
Test 1

Name _____ Date _____

Industrial Mechanics

gear   1. A(n) _____ is a toothed machine element used to transmit motion between rotating shafts.

Mechanical   2. A(n) _____ drive is a system by which power is transmitted from one point to another.

B   3. _____ is the twisting force of a shaft.
- A. Rotation
- B. Torque
- C. Shearing
- D. Bending

C D   ✗ To find lb-in of torque when lb-ft of torque is known, _____.
- A. add 12
- B. subtract 12
- C. multiply by 12
- D. divide by 12

D   5. Horsepower is a unit of power equal to _____.
- A. 746 W
- B. 550 lb-ft/sec
- C. 33,000 lb-ft/min
- D. A, B, and C

drive   6. A(n) _____ gear is any gear that turns or drives another gear.

ratio   7. A(n) _____ is the relationship between two quantities of terms.

idler   8. A(n) _____ gear is a gear that transfers motion and direction in a gear train, but does not change speeds.

T   F   9. The colon is the symbol used to indicate a relation between terms.

T   F   10. Adding an idler gear between a driven and drive gear changes the direction of rotation of the driven gear.

T   **F**   11. The tooth form of a rack gear consists of two flat surfaces.

T   F   12. Backlash is the play between mating gear teeth.

Spur   13. A(n) _____ gear is a gear that has straight teeth that are parallel to the shaft axis.

C   14. Helical gear drive angles may be anywhere from 0° to _____°.
- A. 30
- B. 60
- C. 90
- D. 120

D   15. A compound gear train is _____ or more sets of gears where _____ gear(s) is/are keyed and rotate(s) on one common shaft.
- A. one; one
- B. one; two
- C. two; one
- D. two; two

form   **16.** A tooth _____ is the shape or geometric form of a tooth in a gear when seen as its side profile.

Diametral   **17.** _____ pitch is the ratio of the number of teeth in a gear to the diameter of the gear's pitch circle.

working   **18.** _____ depth is the depth of engagement of two gears.

bevel   **19.** A(n) _____ gear is a gear that connects shafts at an angle in the same plane.

Corrosion   **20.** _____ is the action or process of eating or wearing away gradually by chemical action.

fatigue   **21.** A(n) _____ fracture is a breaking or tearing of gear teeth.

(T)   F   **22.** Rack teeth are gear teeth used to produce linear motion. ✓

T   (F)   **23.** Spur gears are quieter and smoother running than helical gears.

T   (F)   **24.** Under normal conditions, the maximum operating temperature of a gear drive should not exceed 211°F.

(T)   F   **25.** Gear manufacturers design certain parts of a gear train to wear out or break sooner than others.

Gear Terminology

_D_   **1.** Center distance

_L_   **2.** Pinion

_H_   **3.** Gear

_G_   **4.** Pitch circle

_B_   **5.** Outside diameter

_~~Q~~ F_   **6.** Base diameter

_C_   **7.** Base circle

_K_   **8.** Circular pitch

_J_   **9.** Working depth

_I_   **10.** Line of action

_E_   **11.** Clearance

_A_   **12.** Tooth profile (Involute)
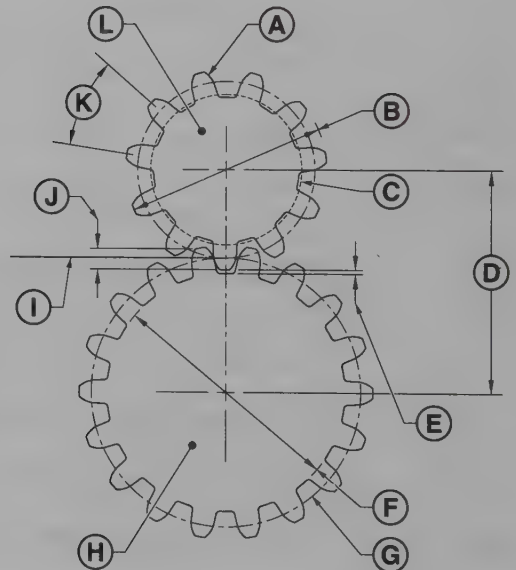
Gears

E   **1.** Miter

G   **2.** Worm

D   **3.** Bevel

H   **4.** Hypoid

B   **5.** Helical

A   **6.** Spur

C   **7.** Rack and pinion

F   **8.** Herringbone

TEETH CUT AT
ANGLE TO AXIS
OF ROTATION

Emerson Power Transmission

(A)
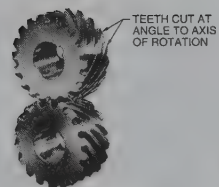
Emerson Power Transmission

(B)
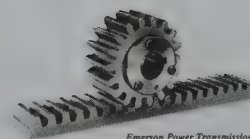
Emerson Power Transmission

(C)
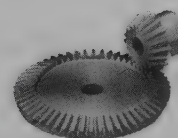
Boston Gear®

(D)

Martin Sprocket & Gear Inc.

(E)
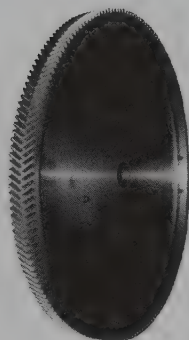
Engelhardt Gear Co.

(F)
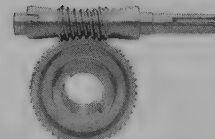
*Cone Drive Operations Inc./
Subsidiary of Textron Inc.*

(G)
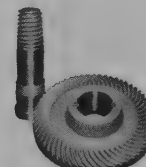
Engelhardt Gear Co.

(H)

Gear Wear

A   **1.** Abrasive wear

B   **2.** Corrosive wear

C   **3.** Electrical pitting

D   **4.** Fatigue wear

SHARP
GEAR
TEETH   GOUGES

SHARP
WEAR
STEPS

(A)

RUST-
COLORED
DEPOSITS   ACID-
ETCHED
PITS

(B)

BURNED
OR FUSED
METAL   SMALL
CRATERS

(C)

CRACKS   FRACTURES

(D)
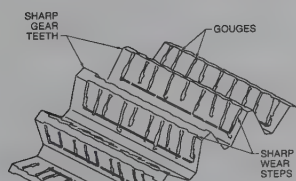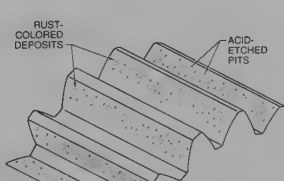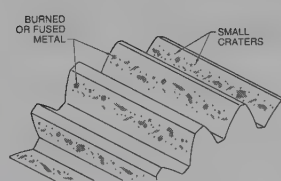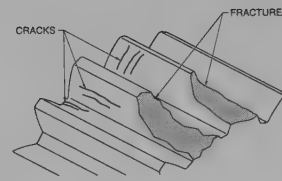
$$F \quad D$$
$$225 = 75 \times 3$$

foot?

Problems

225 lb ft 1. A torque of _____ lb-ft is developed when a 75 lb force is applied at the end of a 3' lever arm.

fase 258 ÷

4.5 lb ft 2. The available torque supplied by a 1.5 HP, 1750 rpm motor is _____ lb-ft.

$$\frac{5252 \times 1.5}{1750} = T$$

2.03 3. _____ HP is required to turn Winch A.

0 × 120 / 60

40 rpm 4. The speed of a 60 tooth driven gear is _____ rpm when the drive gear has 20 teeth and rotates at 120 rpm.

Clockwise 5. Gear A is rotating in a(n) _____ direction.

36 6. Gear A is rotating at _____ rpm.

32 7. A driven gear rotating at 36 rpm requires _____ teeth if the 48 tooth drive gear rotates at 24 rpm.

12.5 8. The diametral pitch (DP) of Gear C is _____

12" DRUM ROTATING AT 8 RPM
HORSEPOWER REQUIRED TO LIFT LOAD = ? HP
TORQUE ON DRUM = 1333.33 LB-FT
2000 LB LOAD
WINCH A

1333.3 × 550

DRIVEN GEAR A ROTATING AT ? RPM
50 TEETH
18 TEETH
DRIVE GEAR B ROTATING AT 100 RPM IN COUNTERCLOCKWISE DIRECTION
GEARS A AND B
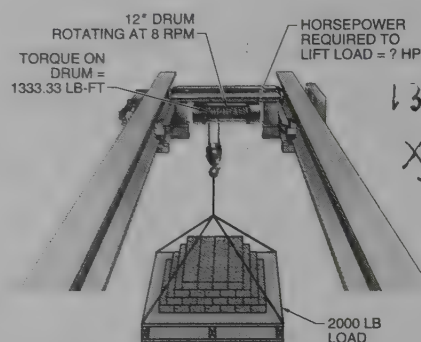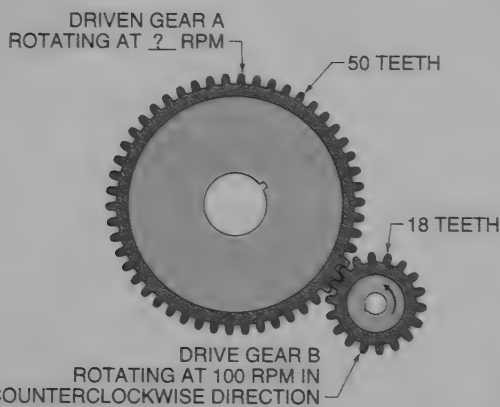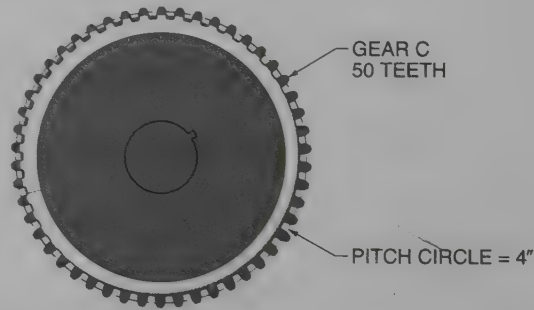
GEAR C 50 TEETH
PITCH CIRCLE = 4"
GEAR C

$$\frac{50}{4}$$

$$36 = \frac{18 \times 100}{50} \qquad \frac{T_1 \times N_1}{T_2} = N_2$$

$$8 \times 2000 \div 12$$
$$\begin{array}{r} 13333 \\ 12\overline{)16000} \\ 12 \\ \hline 40 \end{array}$$

$$T_2 = \frac{T_1 \times N_1}{N_2}$$

$$32 = \frac{48 \times 24}{2}$$

8900
18 900
4.91

Vibration

Chapter 13
Test 1

Name _____ Date _____

Industrial Mechanics

Vibration 1. _____ is a continuous periodic change in displacement with respect to a fixed reference.

C 2. Resonance is the magnification of vibration and its noise by _____% or more.
  - A. 0
  - B. 10
  - C. 20
  - D. neither A, B, nor C

(T) F 3. All objects on earth are constantly experiencing vibration.

(T) F 4. Machines vibrate even when in the best operating condition.

(T) F 5. A vibration cycle is the complete movement from beginning to end of a vibration.

Alignment 6. _____ is the location (within tolerance) of an axis of a coupled machine shaft relative to another.

Peak 7. _____ is the absolute value from a zero point (neutral) to the maximum travel on a waveform.

Waveform 8. A(n) _____ is a graphic presentation of an amplitude as a function of time.

Hertz / 1 Hz 9. **Hertz** is a measurement of frequency equal to 1 cps.

Phase 10. _____ is the position of a vibrating part at a given moment with reference to another vibrating part at a fixed reference point.

386 11. The peak value of acceleration is measured in units of g peak, where 1 g is equal to _____ ips^2.

Transducer 12. A(n) _____ is a device that converts a physical quantity into another quantity.

eddy 13. A(n) _____ current is an electric current that is generated and dissipated in a conductive material in the presence of an electromagnetic field.

T (F) 14. Vibration may occur only from North to South.

T (F) 15. A logarithmic scale is an amplitude or frequency displayed in powers of 100.

domain 16. Time _____ is the amplitude as a function of time.

displacement 17. _____ is the measurement of the distance (amplitude) an object is vibrating.

order 18. A(n) _____ is a multiple of a running speed (rpm) frequency.

3 19. Transducers used to measure radial vibration must be attached within _____ " of the bearing.

_50%_
ot means square to

20. More than _____% of all rotary equipment failures are related to vibration.

rms

21. _____ is the square root of the sum of a set of squared instantaneous values.

domain

22. Frequency _____ is the amplitude versus frequency spectrum observed on an FFT analyzer.

T   F

23. Vibration significantly reduces the expected life of bearings and rotating shaft seals.

T   (F)

24. A change in the vibration signature of a machine indicates the ending of a defect.

T   (F)

25. Linear amplitude spectra are amplitude signals displayed in powers of 10.

filter

26. A(n) _____ is a device that limits vibration signals so only a single frequency or group of frequencies can pass.

trending

27. _____ is a graphic display used for interpretation of machine characteristics.

whirl

28. Oil _____ is the buildup and resistance of a lubricant in a rolling-contact bearing that is rotating at excessive speeds.

(T)   F

29. Piezoelectric is the production of electricity by applying pressure to a crystal.

(T)   F

30. The magnitude of vibrations felt by humans is extremely small.

Unbalanced Vibrations

_C_

1. Coupling unbalance

_A_

2. Equal rotor unbalance

_B_

3. Opposing forces rotor unbalance

(A)

(B)

(C)
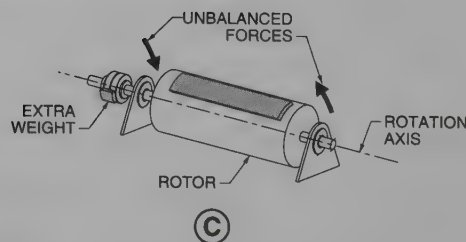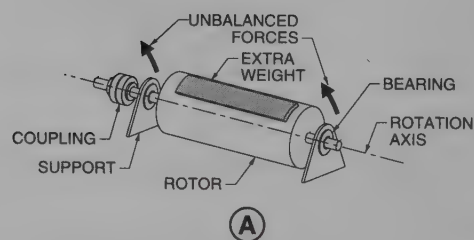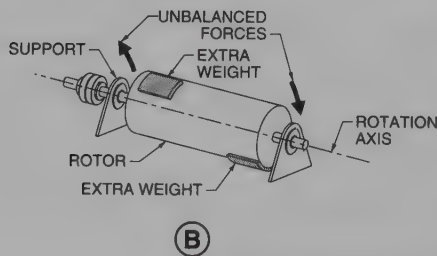
Waveform Spectrum

_____ A _____ **1.** Vibration waveform

_____ B ❷ _____ **2.** Peak amplitude

_____ C _____ **3.** Peak-to-peak amplitude

_____ D _____ **4.** 1 cycle or 1 frequency in time
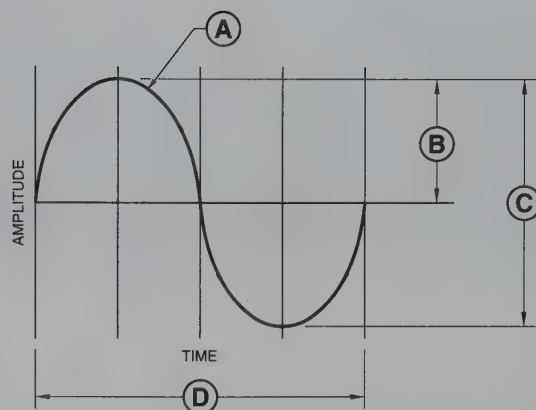
Vibration Acceleration

_____ C _____ **1.** Time

_____ E _____ **2.** Amplitude

_____ B _____ **3.** Peak velocity

_____ A _____ **4.** Peak acceleration

_____ D _____ **5.** Peak-to-peak displacement
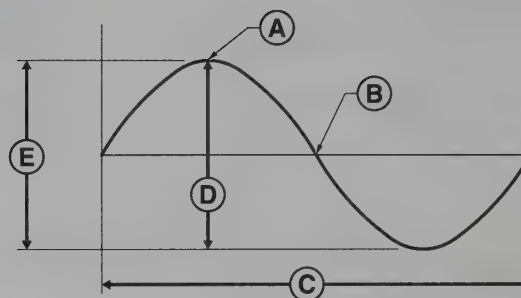
Displacement

_____ A _____ **1.** Positive upper limit

_____ D _____ **2.** Positive lower limit

_____ B _____ **3.** Displacement

_____ C _____ **4.** Peak-to-peak displacement
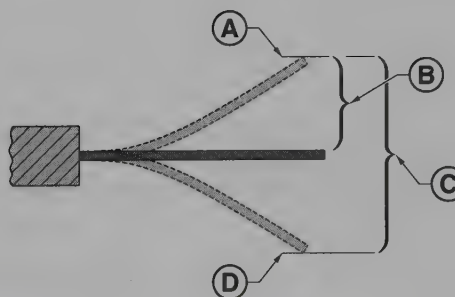
Vibration Transducers

_____ A _____   **1.** Velocity

_____ B _____   **2.** Accelerometer

_____ C _____   **3.** Displacement

SHELL

LEADS

COIL

PERMANENT
MAGNET

LIGHT
SPRING

DAMPENING
FLUID

A

ELECTRONICS

MASS

PIEZOELECTRIC
ELEMENT

LEADS

SHELL

HEX NUT

CONNECTOR

B

TRANSDUCER
(PROBE)

LOCK NUT

MACHINE BODY

LEADS

SHAFT

GAP

C

100
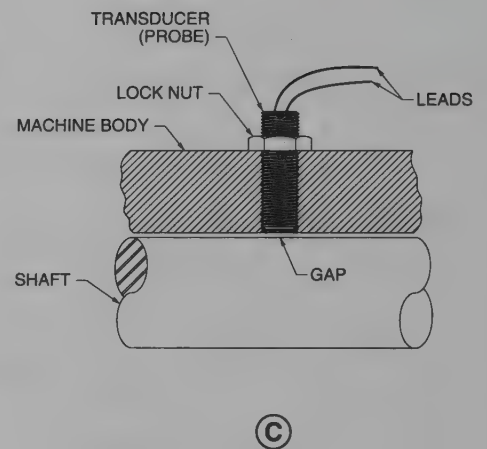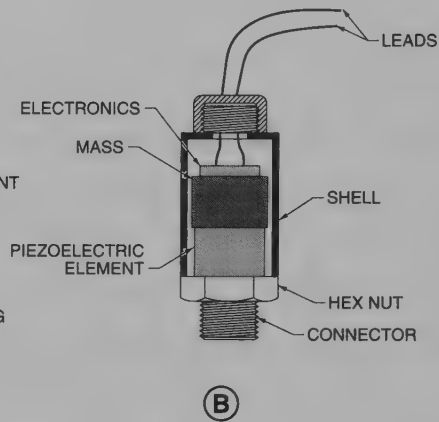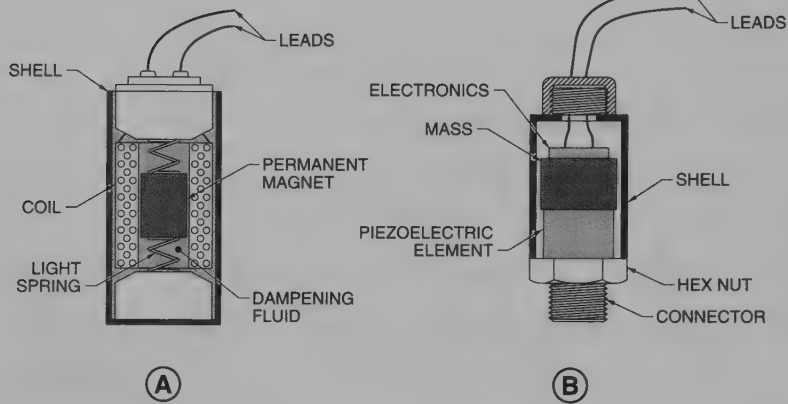
Industrial Mechanics

Alignment **1.** _____ is the location (within tolerance) of one axis of a coupled machine shaft relative to that of another.

misalignment **2.** _____ is the condition where the centerlines of two machine shafts are not aligned within tolerances.

Thermal **3.** _____ expansion is the dimensional change in a substance due to a change in temperature.

Coupling **4.** A(n) _____ is a device that connects the ends of rotating shafts.

C **5.** _____ is the process of pressing the start switch of a machine to determine if the machine starts when it is not supposed to start.

A. Bumping   C. Challenging
B. Skipping   D. neither A, B, nor C

A **6.** Shim stock is steel material manufactured in various thicknesses, ranging from _____ ″ to _____ ″.

A. .0005; .125   C. .0005; .0125
B. .005; .125   D. neither A, B, nor C

base **7.** A(n) _____ plate is a rigid steel support for firmly coupling and aligning two or more rotating devices.

anchoring **8.** _____ is any means of fastening a mechanism securely to a base or foundation.

T (F) **9.** Dowel effect is corrected by using machined washers 2 to 5 times thicker than the original washer.

(T) F **10.** Jack screws are used for machine movement only.

(T) F **11.** Runout is a radial variation from a true circle.

(T) F **12.** Always choose the combination that uses the least amount of shims or spacers where different shim or spacer combinations can be chosen.

laser **13.** Good shim packs are _____ cut with each size printed on the shim.

12 o'clock **14.** The top position, when using a dial indicator, is the _____ position.

taper **15.** A(n) _____ gauge is a flat, tapered strip of metal with graduations in thousandths of an inch or millimeters marked along its length.

float **16.** Axial _____ is the axial movement of a shaft due to bearing and bearing housing clearance.

_B_   **17.** When using the combination rim-and-face alignment method, offset misalignment in the vertical plane is checked by measuring the rim of the coupling at the _____ and _____ positions.
  A. 12:00; 3:00   C. 12:00; 9:00
  B. 12.00; 6:00   D. 3:00; 9:00

_D_   **18.** When using the combination rim-and-face alignment method, offset misalignment in the horizontal plane is checked by measuring the rim of the coupling at the _____ and _____ positions.
  A. 12:00; 3:00   C. 12:00; 9:00
  B. 12.00; 6:00   D. 3:00; 9:00

offset   **19.** _____ misalignment is a condition where two shafts are parallel but are not on the same axis.

Angular   **20.** _____ misalignment is a condition where one shaft is at an angle to the other shaft.

soft   **21.** _____ foot is a condition that occurs when one or more feet of a machine do not make complete contact with its base.

jack   **22.** A(n) _____ screw is a screw inserted through a block that is attached to a machine base plate allowing for ease in machine movement.

(T) F   **23.** The objective of proper alignment is to align the shafts, not the couplings.

T (F)   **24.** A spacer is steel material used for filling spaces ¼″ or less.

(T) F   **25.** Precut stainless steel shims are recommended for alignment purposes.

Soft Foot

_B_   **1.** Angular

_A_   **2.** Parallel

_C_   **3.** Springing

_D_   **4.** Induced

A
FOOT PARALLEL BUT NOT ON SAME PLANE AS OTHERS
BASE PLATE

B
MOTOR — FOOT NOT PARALLEL TO OTHERS
STEPPED SHIMS
BASE PLATE
HIDDEN ANGULAR SOFT FOOT
BASE PLATE

C
MOTOR
BENT, RUSTY, BURRED SHIMS OR PAINT AND DIRT
BASE PLATE
FOUNDATION

D
UNSUPPORTED FORCES
APPLIED PRESSURES
PUMP
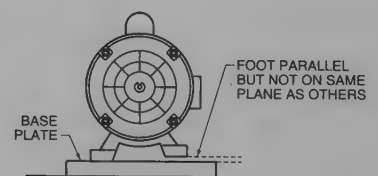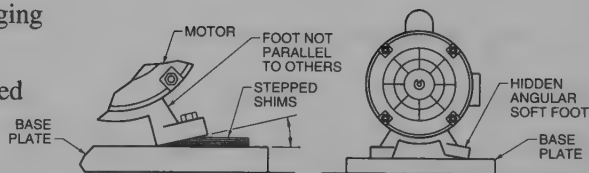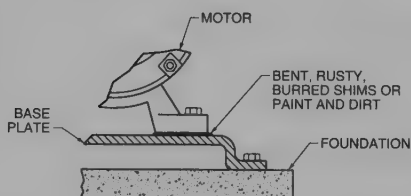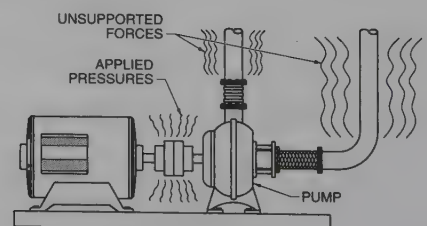
Misalignment

_A_____   1. Offset

_C_____   2. Angular

_B_____   3. Offset and angular

TWO SHAFTS PARALLEL
BUT NOT ON SAME AXIS

Ⓐ

TWO SHAFTS ON DIFFERENT
AXES AND AT DIFFERENT ANGLES

ONE SHAFT AT
ANGLE TO
OTHER SHAFT

Ⓑ

Ⓒ
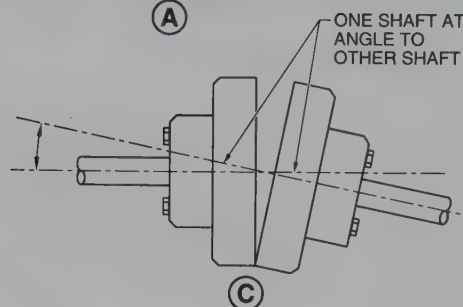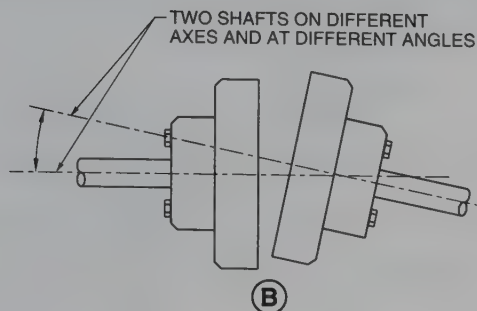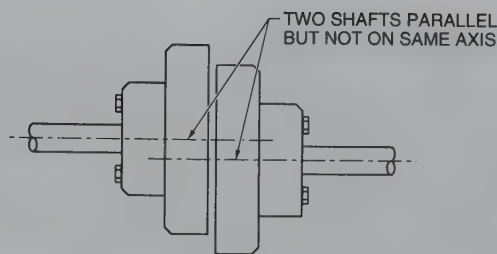
Shaft Runout

_A_____   1. Bent shaft

_B_____   2. Eccentric circular path

_C_____   3. Poorly machined shaft

ROTATION

Ⓐ   Ⓑ   Ⓒ
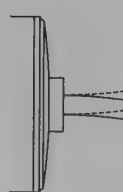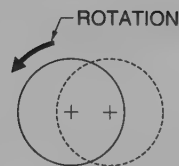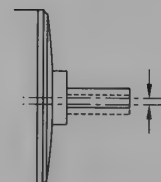
Dial Indicator Readings

_A_____   1. The dial indicators at A show a TIR of _.019_ ".

_B_____   2. The dial indicators at B show a TIR of _.024_ ".

_C_____   3. The dial indicators at C show a TIR of _.028_ ".

+0.025"   BEGIN   +0.006"   END   −0.006"   BEGIN   −0.030"   +0.022"   BEGIN   −0.006"   END

10 -0+ 10   10 -0+ 10   10 -0+ 10   10 -0+ 10   10 -0+ 10   10 -0+ 10
20 20   20 20   20 20   20 20   20 20   20 20
30 30   30 30   30 30   30 30   30 30   30 30
40 50 40   40 50 40   40 50 40   40 50 40   40 50 40   40 50 40

PROBE   END

Ⓐ   Ⓑ   Ⓒ
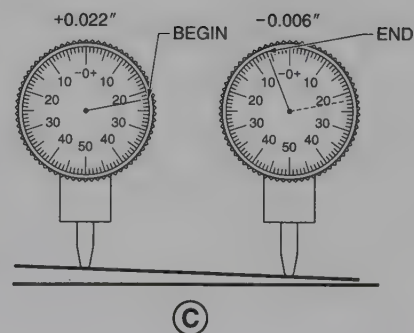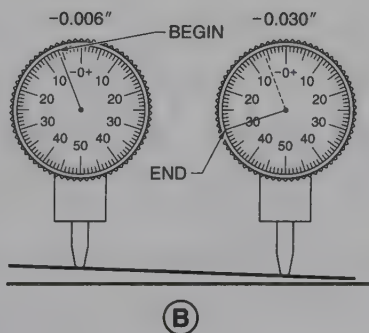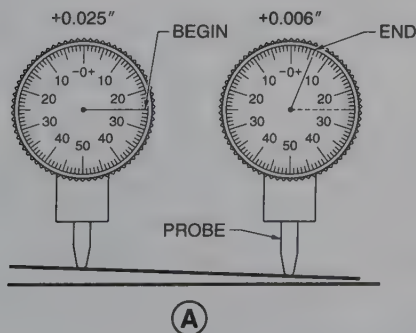
Anchoring Characteristics

_A_ **1.** Proper anchoring

_D_ **2.** Bolt bound

_E_ **3.** Excess bolt body

_B_ **4.** Bolt bottoms out

_C_ **5.** Dowel effect

ANCHOR BOLT
WASHER
SHIMS
BASE PLATE
LOCK WASHER
NUT
MACHINE FOOT
(A)

GAP
WASHER
(B)

WEAK SUPPORT FORCES WASHER INTO HOLE DISALLOWING SIDE MOVEMENT
SHIMS
(C)

NO ROOM TO MOVE
SHIMS
(D)

GAP
NOT ENOUGH THREAD
SHIMS
(E)
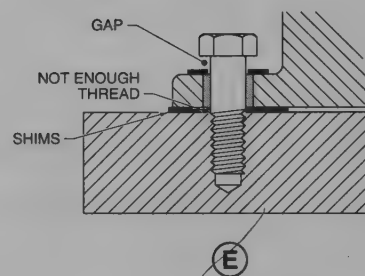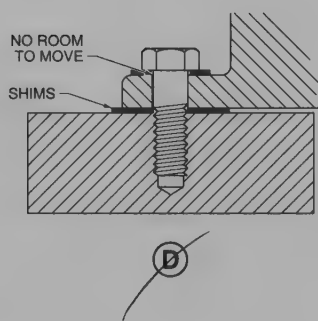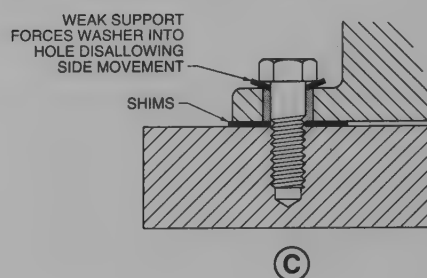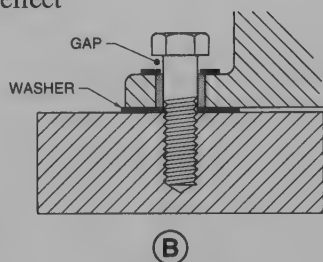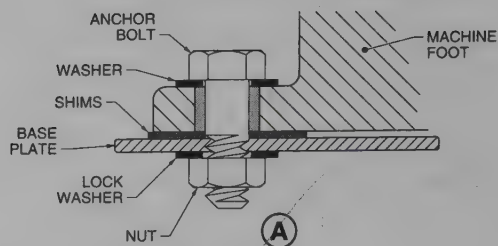
Alignment Methods

_A_ **1.** Straightedge

_B_ **2.** Rim-and-face

_C_ **3.** Reverse dial

_D_ **4.** Electronic reverse dial

_E_ **5.** Laser rim-and-face

GAP
(A)

(B)

DIAL INDICATOR AT 12:00
DIAL INDICATOR AT 6:00
(C)

WIRES TO COMPUTER/CALCULATOR
PROBE
(D)

LASER BEAMS
WIRES TO COMPUTER
(E)
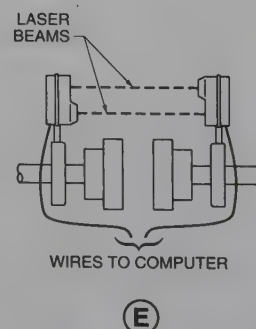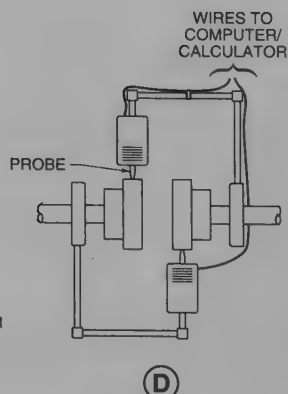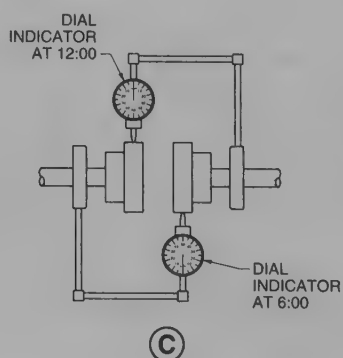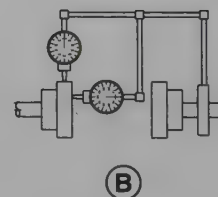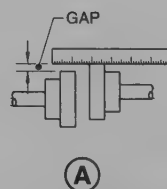
Industrial Mechanics

Static   **1.** _____ electricity is the accumulation of charge.

Dynamic   **2.** _____ electricity is electron flow from one atom to another.

Valence   **3.** A(n) _____ shell is the outermost shell of an atom.

Voltage   **4.** _____ is the amount of electrical pressure in a circuit.

Ohm's   **5.** _____ law is the relationship between voltage, current, and resistance in a circuit.

Magnet   **6.** A(n) _____ is a device that attracts iron and steel because of the molecular alignment of its material.

Direct   **7.** _____ current is a flow of electrons in only one direction.

Grounding   **8.** _____ is the connection of all exposed noncurrent-carrying metal parts to the earth.

Continuity   **9.** A(n) _____ tester is a device that indicates if a circuit is open or closed.

Multimeter   **10.** A(n) _____ is a test tool used to measure two or more electrical values.

transformer   **11.** A(n) _____ is an electric device that uses electromagnetism to change voltage from one level to another.

(T) F   **12.** Fuses or circuit breakers may be bimetallic.

(T) F   **13.** A fault current as low as 4 mA to 6 mA will activate a GFCI and interrupt the circuit.

T (F)   **14.** Lightning is the number one cause of fires.

(T) F   **15.** Resistance is the opposition to electron flow.

flux   **16.** Magnetic _____ lines are the invisible lines of force that make up a magnetic field.

Generator   **17.** A(n) _____ is a device that converts mechanical energy into electrical energy.

_AC_   **18.** _____ current is a flow of electrons that reverses its direction of flow at regular intervals.

distribution   **19.** Power _____ is the process of delivering electrical power to where it is needed.

AHJ   **20.** The _____ is responsible for enforcing the NEC®.

fuse   **21.** A(n) _____ is an overcurrent device with a fusible link that melts and opens the circuit of an overcurrent condition.

(T) F **22.** A circuit breaker is a device with a mechanical mechanism that may manually or automatically open a circuit when an overload condition or short circuit occurs.

T (F) **23.** A switch is open when it allows current to flow in a circuit.

(T) F **24.** A solenoid is a device that converts electrical energy to a linear, mechanical force.

GFCI **25.** A(n) _____ is an electrical device that protects personnel by detecting potentially hazardous ground faults and quickly discontinuing power from the circuit.

Hydrogen Atom

_____ **1.** Electron

_____ **2.** Neutron

_____ **3.** Proton

_____ **4.** Nucleus

_____ **5.** Shell
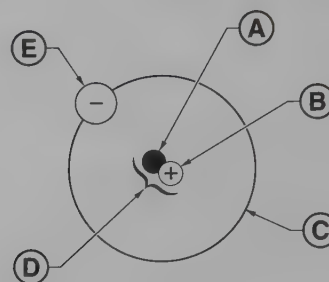
Hazardous Locations

B **1.** Class I

C **2.** Class II

D **3.** Class III

E **4.** Division I

A **5.** Division II

A. Hazardous location in which hazardous substance is not normally present in air in sufficient quantities to cause an explosion or ignite hazardous materials.

B. Sufficient quantities of flammable gases and vapors present in air to cause an explosion or ignite hazardous materials.

C. Sufficient quantities of combustible dust are present in air to cause an explosion or ignite hazardous materials.

D. Easily-ignitable fibers or flyings are present in air, but not in a sufficient quantity to cause an explosion or ignite hazardous materials.

E. Hazardous location in which hazardous substance is normally present in air in sufficient quantities to cause an explosion or ignite hazardous materials.

Testing Contactors and Motor Starters

1. Connect the voltage tester at A to check the incoming voltage.
2. Connect the voltage tester at B to check the control voltage.
3. Connect the voltage tester at C to check the output voltage.

POWER CIRCUIT

CONTROL
SWITCH

TO LOAD

Ⓐ Ⓑ Ⓒ
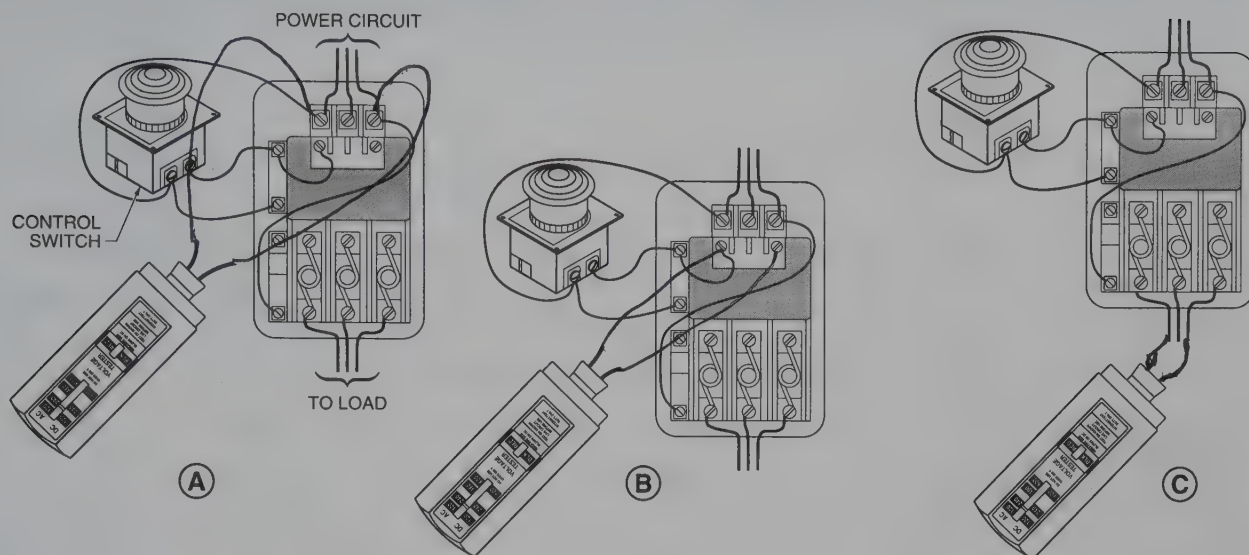
Testing Solenoids

C 1. Reading if coil is normal.

A 2. Reading if coil has a broken wire.

B 3. Reading if coil is shorted.

$0\ \Omega$ O.L. $100\ \Omega$

Ⓐ Ⓑ Ⓒ
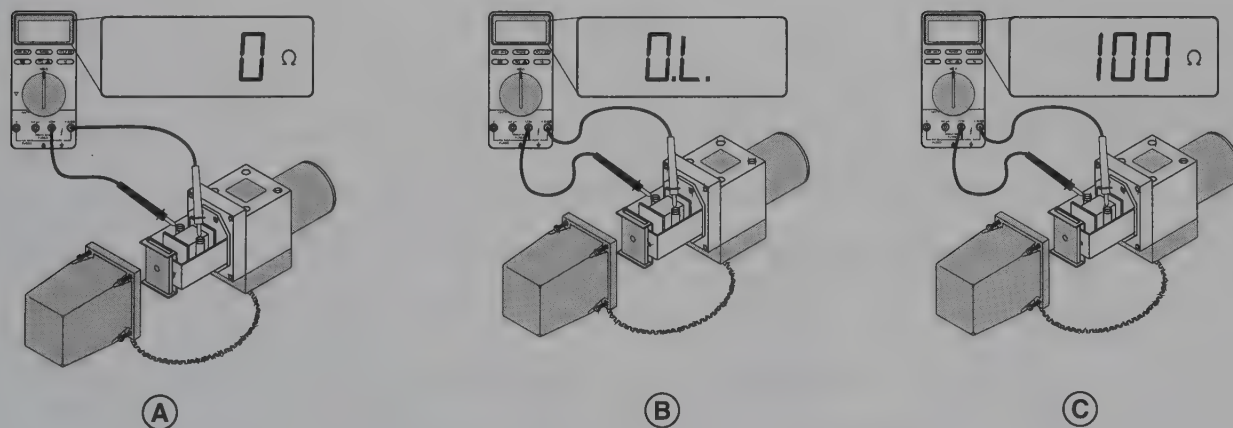
Effect of Electric Current

_____A_____   **1.** Current in 100 W lamp can electrocute 20 adults

_____B_____   **2.** Heart convulsions; usually fatal

_____C_____   **3.** Painful shock; inability to let go

_____D_____   **4.** Safe values

_____E_____   **5.** No sensation

CURRENT
1000 mA — Ⓐ
50 mA — Ⓑ
15 mA TO 20 mA — Ⓒ
0 mA TO 5 mA — Ⓓ
1 mA
0 mA — }Ⓔ
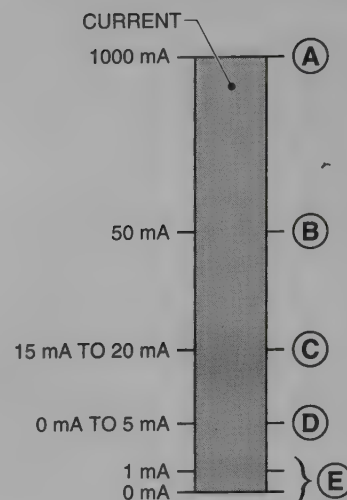
Electrical Safety

Write five electrical safety rules that should be practiced by all personnel working with electricity.

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

5. _____

_____

_____

99

Final Exam

Name _____ Date _____

Industrial Mechanics

T F   **1.** All circles contain 360°.

T **F**   **2.** Sealed bearings should be relubricated on a regularly-scheduled basis.

T F   **3.** Torque is the twisting (rotational) force of a shaft.

T F   **4.** The velocity of a fluid decreases as the cross-sectional area of a pipe increases.

T F   **5.** Polygons are named according to their number of sides.

liquid   **6.** A(n) _____ is a fluid that can flow readily and assume the shape of its container.

bearing   **7.** A(n) _____ is a machine part that supports another part, such as a shaft, which rotates or slides in or on it.

_A_   **8.** Area is always expressed in _____ units.

      A. square   C. either A or B
      B. cubic   D. neither A nor B

T F   **9.** Angles are measured in degrees, minutes, and seconds.

_D_   **10.** Lubricants are used to _____.

      A. reduce friction   C. prevent corrosion
      B. prevent wear   D. A, B, and C

Ferrous   **11.** _____ metals are metals containing iron.

T F   **12.** Backlash is the play between mating gear teeth.

12 o'clock   **13.** The top position, when using a dial indicator, is the _____ position.

Lifting   **14.** _____ is hoisting equipment or machinery by mechanical means.

_C_   **15.** _____ is a measure of a component's or system's useful output energy.

      A. Rate   C. Efficiency
      B. Percentage   D. Value

T F   **16.** Machines vibrate even when in the best operating condition.

Volume   **17.** _____ is the three-dimensional size of an object measured in cubic units.

_B_   **18.** _____ is the twisting force of a shaft.

      A. Rotation   C. Shearing
      B. Torque   D. Bending

Symetrical 19. A(n) _____ load is a load in which one-half of the load is a mirror image of the other half.

B 20. Fixed ladders are installed in a preferred pitch range between _____° and 90° from horizontal.

    A. 45   C. 75
    B. 60   D. neither A, B, nor C

Alignment 21. _____ is the location (within tolerance) of one axis of a coupled machine shaft relative to that of another.

Kinetic 22. _____ energy is the energy of motion.

AC 23. _____ current is a flow of electrons that reverses its direction of flow at regular intervals.

Lubrication 24. _____ is the process of maintaining a fluid film between solid surfaces to prevent their physical contact.

4' 25. Metal ladders should not be used within _____' of electrical circuits or equipment.

C 26. A binary system has _____ value(s).

    A. no   C. two
    B. one   D. any number of

hydraulics 27. _____ is the branch of science that deals with the practical application of water or other liquids at rest or in motion.

(T) F 28. Walking requires friction between the feet and floor in order to move.

T **(F)** 29. A square foot contains 12 sq in.

outside 30. The diameter of wire rope is determined by the largest possible _outside diameter_ dimension.

C 31. One horsepower is the amount of energy required to lift _____ lb 1' in 1 min.

    A. 330   C. 33,000
    B. 550   D. 55,000

atom 32. A(n) _____ is the smallest building block of matter than cannot be divided into smaller units without changing its basic character.

Standard 33. _____ V-belts are designated as A, B, C, D, or E.

cabling 34. _____ is a rope's attempt to rotate and untwist its strand lays while under stress.

formula 35. A(n) _____ is a mathematical equation that contains a fact, rule, or principle.

14.7 36. The weight of the atmosphere at sea level is _____ psi.

(T) F 37. The total amount of moisture that air is capable of holding varies based on the temperature of the air.

(T) F 38. The objective of proper alignment is to align the shafts, not the couplings.

T **(F)** 39. For optimum efficiency, a V-belt should touch the bottom of the pulley.

T **(F)** 40. A 10 weight oil is thicker than a 40 weight oil.

Circuit 41. A(n) _____ is a closed path through which hydraulic fluid flows or may flow.

Static 42. _____ lift is the height to which atmospheric pressure causes a column of fluid to rise above the supply to restore equilibrium.

T   F   **43.** Bearings should never be struck with a hammer.

T   F   **44.** There are 60′ in one degree.

_____C_____   **45.** Guardrails on scaffolds must be installed no less than _____″ or more than _____″ high, with a midrail.

        A. 24; 30   C. 36; 42

        B. 30; 36   D. 42; 48

T   F   **46.** Electric motors are less efficient than air motors.

_____C_____   **47.** Atoms combine to form _____.

        A. protons   C. molecules

        B. particles   D. neither A, B, nor C

___Hertz___   **48.** _____ is a measurement of frequency equal to 1 cps.

___barometer___   **49.** A mercury _____ is an instrument that measures atmospheric pressure using a column of mercury.

T   F   **50.** A straight angle always contains 90°.

T   F   **51.** Ambient temperature is the temperature of the air surrounding a piece of equipment.

_____0_____   **52.** A pressure gauge reads _____ psig at normal atmospheric pressure.

___reciprocating___   **53.** _____ pistons move forward and backward alternately.

T   F   **54.** A switch is open when it allows current to flow in a circuit.

_____C_____   **55.** A Bourdon tube is a hollow metal tube made of brass or similar material and is _____.

        A. elliptical in cross-sectional area   C. both A and B

        B. bent in a C-shape   D. neither A nor B

_____C_____   **56.** During startup of a machine, oil _____.

        A. is cool   C. A and B

        B. does not flow easily   D. neither A nor B

___Zero___   **57.** Absolute _____ is the temperature at which substances possess no heat.

T   F   **58.** A machine should never be grounded by connecting a wire from the machine to a gas or oil pipe.

___offset___   **59.** _____ misalignment is a condition where two shafts are parallel but are not on the same axis.

___hypotenuse___   **60.** The _____ is the side of a right triangle opposite the right angle.

T   F   **61.** The higher the mesh number of a strainer, the smaller the opening.

___displacement___   **62.** _____ is the measurement of the distance (amplitude) an object is vibrating.

T   F   **63.** A person should always face the ladder when ascending or descending.

T   F   **64.** A better finish on a bearing produces less friction.

___Center of gravity___   **65.** The _____ is the balancing point of a load.

___pneumatics___   **66.** _____ is the branch of science that deals with the transmission of energy using a gas.

T   F   **67.** In a bevel gear, the drive gear is the smaller gear.

gear **68.** A(n) _____ is a toothed machine element used to transmit motion between rotating shafts.

T (F) **69.** Static energy is the energy of motion.

AHJ **70.** The _____ is responsible for enforcing the NEC®.

Problems

_706.86_ **1.** The area of Circle A is _____ sq in.

_2.1818_ **2.** The horsepower required to lift load B is _____ HP.

_60_ **3.** The area of Surface A on Block C is _____ sq in.

_540_ **4.** The volume of Block C is _____ cu in.

_375_ **5.** _____ lb of effort force is required to lift the resistance force of Fulcrum D.

_8.727_ **6.** The horsepower required to lift the 6 t load is _____ HP.

_542 °R_ **7.** The temperature on the Fahrenheit scale equals _____ °R.

_273.33_ **8.** The driven pulley speed at E is _____ rpm.

$$2.1818 = \frac{6000}{2750} = \frac{500 \times 12}{550 \times 5}$$

CIRCLE A — 15"

500 LB / 500 LB — 12' — LOAD B — 5 SEC

BLOCK C — 3", B, A, 20", C, 9"

FULCRUM D: $F_1 = ?\ LB$ $F_2 = 1500\ LB$ $d_1 = 20'$ $d_2 = 5'$
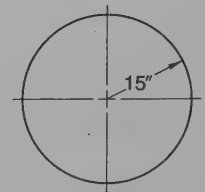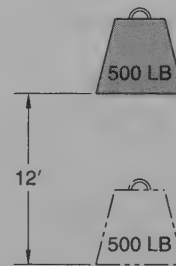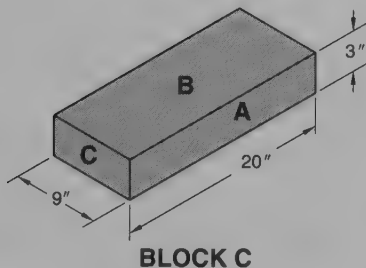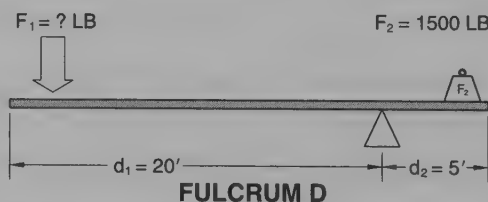
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$$\frac{1500 \times 5}{20} = \frac{7500}{20} \quad 375$$

°F — 82°

$$\frac{460}{82}$$
$$\overline{542}$$

6 T — 4' — 6 T — 10 SEC

$$\frac{12000 \times 4}{550 \times 10}$$

$$8.7272 \quad \frac{48,000}{5500}$$

36" — 12" D — 4" D — 820 RPM DRIVE PULLEY — ? RPM DRIVEN PULLEY — (E)
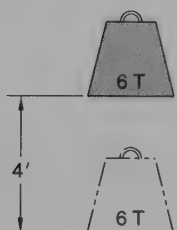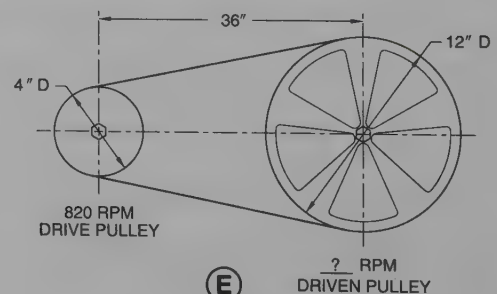
$$\times 273.33$$

$$4 \times 820$$

Appendix

WEIGHT OF STEEL AND BRASS BAR STOCK*			
Diameter or Thickness**	Round Steel	Square Steel	Brass
¼	.167	—	.181
½	.667	—	.724
¾	1.50	—	1.63
1	2.67	3.4	2.89
1¼	4.17	—	4.52
1½	6.01	7.7	6.51
1¾	8.18	—	8.86
2	10.68	—	11.57
4	42.7	54.4	—
5	66.8	85.0	—
6	96.1	122.4	—
10	267.0	340.0	—
12	384.5	489.6	—

* in lb/ft
** in in.

WEIGHT OF STEEL PLATE*	
Thickness**	Weight
1/16	2.55
⅛	5.1
3/16	7.65
¼	10.2
5/16	12.75
⅜	15.3
½	20.4
⅝	25.5
¾	30.6
1	40.8
1¼	51.0
1½	61.2
2	81.6

* in lb/sq ft
** in in.

LEAD LINE FACTORS*

Parts of Line	Plain Bearing Pulleys	Rolling-Contact Bearing Pulleys
1	1.09	1.04
2	.568	.530
3	.395	.360
4	.309	.275
5	.257	.225
6	.223	.191
7	.199	.167
8	.181	.148
9	.167	.135
10	.156	.123
11	.147	.114
12	.140	.106
13	.133	.100
14	.128	.095
15	.124	.090

* based on equal number of pulleys

SLING EYEBOLT CAPACITY LOSS

Sling Angle*	Capacity Reduction**
90	100
60 – 89	70
45 – 59	30
Less than 45	25

* in degrees
** in %

SLING ROPE LOAD CAPACITY 6 x 19 CLASSIFICATION (2000 LB TON)

Rope Dia*	Choker	Vertical Load	2-Leg 30°	2-Leg 45°	2-Leg 60°
$\frac{1}{4}$	.35	.65	.58	.50	.31
$\frac{3}{8}$	.84	1.8	1.68	1.37	.95
$\frac{1}{2}$	1.50	2.50	2.96	2.41	1.71
$\frac{3}{4}$	3.20	6.0	6.58	5.37	3.80
1	5.5	10.0	11.56	9.44	6.58

* in in.

VERTICAL SLING COMPONENT LOAD CAPACITY 6 x 19 IPS-FC CLASSIFICATION* (2000 LB TON)

Rope Dia**	Spelter/ Swaged	U-Bolt	Wedge	Mechanical Splice
$\frac{1}{4}$	.54	.43	.43	.49
$\frac{3}{8}$	1.22	.97	.97	1.09
$\frac{1}{2}$	2.14	1.71	1.71	1.92
$\frac{3}{4}$	4.76	3.80	3.80	4.28
1	8.36	6.68	6.68	7.52
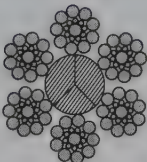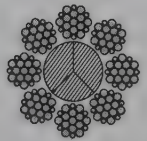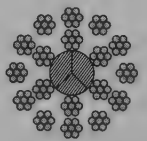
* rates include safety factor of 5
** in in.

SLING ANGLE LOSS FACTORS

Angle from Horizontal*	Loss Factor
90	1.000
85	.996
80	.985
75	.966
70	.940
65	.906
60	.866
55	.819
50	.766
45	.707
40	.643
35	.574
30	.500

* in degrees

ROPE BENDING EFFICIENCY
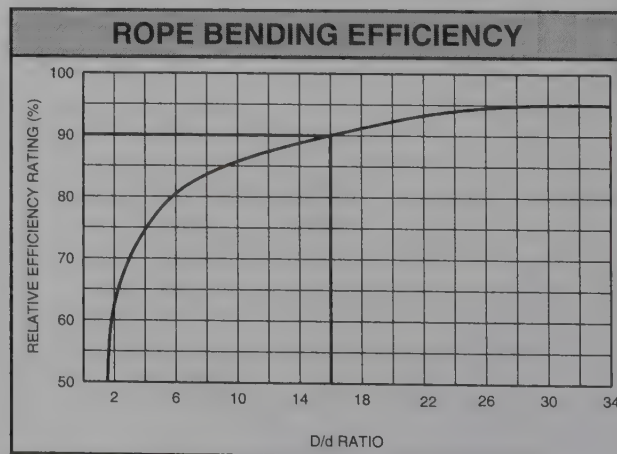
WIRE ROPE STRENGTH

Nominal Diameter*	Classification	Nominal Breaking Strength per 2000 lb Ton	
		IPS**	EIPS†
1/4	6 x 19 STANDARD HOISTING FIBER CORE	2.74	–
	6 x 19 STANDARD HOISTING IWRC	–	3.40
	8 x 19 SPECIAL FLEXIBLE HOISTING FIBER CORE	2.35	–
	18 x 7 NONROTATING	2.51	–
3/8	6 x 19 STANDARD HOISTING FIBER CORE	6.10	–
	6 x 19 STANDARD HOISTING IWRC	–	7.55
	8 x 19 SPECIAL FLEXIBLE HOISTING FIBER CORE	5.24	–
	18 x 7 NONROTATING	5.59	–
1/2	6 x 19 STANDARD HOISTING FIBER CORE	10.7	–
	6 x 19 STANDARD HOISTING IWRC	–	13.3
	8 x 19 SPECIAL FLEXIBLE HOISTING FIBER CORE	9.23	–
	18 x 7 NONROTATING	9.85	–

STANDARD HOISTING
6 x 19 SEALE
WITH FIBER CORE

SPECIAL FLEXIBLE HOISTING
8 x 19 WARRINGTON
WITH FIBER CORE

NONROTATING WIRE ROPE
18 x 7
WITH FIBER CORE

* in in.
** IPS - improved plow steel
† EIPS - extra improved plow steel

POLE SCAFFOLD COMPONENTS*

Type	Poles	Bearers	Ledgers (Stringers)	Braces	Planking	Rails
Light-duty** single-pole	20' or less – 2 × 4 60' or less – 4 × 4	3' width – 2 × 4 5' width – 4 × 4	20' or less – 1 × 4 60' or less – 1¼ × 9	1 × 4	2 × 10	2 × 4
Medium-duty† single-pole	60' or less – 4 × 4	2 × 10	2 × 10	1 × 6	2 × 10	2 × 4
Heavy-duty‡ single-pole	60' or less – 4 × 4	2 × 10	2 × 10	2 × 4	2 × 10	2 × 4
Light-duty* double-pole	20' or less – 2 × 4 60' or less – 4 × 4	3' width – 2 × 4 5' width – 4 × 4	20' or less – 1¼ × 4 60' or less – 1¼ × 9	1 × 4	2 × 10	2 × 4
Medium-duty† double-pole	60' or less – 4 × 4	2 × 10	2 × 10	1 × 6	2 × 10	2 × 4
Heavy-duty‡ double-pole	60' or less – 4 × 4	2 × 10	2 × 10	2 × 4	2 × 10	2 × 4

* all members except planking are used on edge

** not to exceed 25 lb/sq ft

† not to exceed 50 lb/sq ft

SLING VERTICAL CAPACITIES						
	Class 5**			Class 7†		
Width*	Types I, II, III, IV	Type V	Type VI	Types I, II, III, IV	Type V	Type VI
1	1100	2200	—	1600	3200	—
1½	1600	3200	—	2300	4600	—
1¾	1900	3800	—	2700	5400	—
2	2200	4400	3600	3100	6200	5800
3	3300	6600	—	4700	9400	—
3½	—	—	5800	—	—	8400
4	4400	8800	6800	6200	12,400	11,000
5	5500	11,000	—	7800	15,600	—
6	6600	13,200	10,000	9300	18,600	16,000

* in in.
** minimum certified tensile strength of 6800 lb per in. of width
† minimum certified tensile strength of 9800 lb per in. of width

ROUND SLING COLOR AND CAPACITY RATING*					
Round Sling Size No.	Color	Vertical	Choker	Vertical Basket	45° Basket
		Weight	Weight	Weight	Weight
1	Purple	2600	2100	5200	3700
2	Green	5300	4200	10,600	7500
3	Yellow	8400	6700	16,800	11,900
4	Tan	10,600	8500	21,200	15,000
5	Red	13,200	10,600	26,400	18,700
6	White	16,800	13,400	33,600	23,800
7	Blue	21,200	17,000	42,400	30,000
8	Orange	25,000	20,000	50,000	35,400
9	Orange	31,000	24,800	62,000	43,800
10	Orange	40,000	32,000	80,000	56,600
11	Orange	53,000	42,400	106,000	74,900
12	Orange	66,000	52,800	132,000	93,000

* in lb

ATMOSPHERIC PRESSURE VS LIFT

Altitude above Sea Level*	Barometer Reading**	Atmospheric Pressure†	Theoretical Lift at Standard Temperature of 62°F*
0	29.92	14.7	34
1000	28.8	14.2	33
2000	27.7	13.6	31.5
3000	26.7	13.1	30.2
4000	25.7	12.6	29.1
5000	24.7	12.1	28
6000	23.8	11.7	27
7000	22.9	11.2	26
8000	22.1	10.8	25
9000	21.2	10.4	24
10,000	20.4	10.0	23

* in ft
** in in. Hg
† in psi

SLING MATERIAL STRENGTH CAPACITIES*

6 x 19

ROPE DIA**	VERTICAL	CHOKER	BASKET
$\frac{1}{4}$	.51	.38	1.0
$\frac{5}{16}$	.79	.60	1.6
$\frac{3}{8}$	1.1	.85	2.2
$\frac{7}{16}$	1.5	1.1	3.0
$\frac{1}{2}$	2.0	1.5	4.0
$\frac{9}{16}$	2.5	1.9	5.0
$\frac{5}{8}$	3.1	2.3	6.2
$\frac{3}{4}$	4.4	3.3	8.8
$\frac{7}{8}$	6.0	4.5	12.0
1	7.7	5.9	15.0

Rated Capacities (in Tons)†

* improved plow steel/fc
** in in.
† rates include safety factor of 5

EXTENSION LADDER SECTION OVERLAP

Ladder Length*	Overlap*
8 to 36	3
36 to 48	4
48 to 60	5

* in ft

CHOKER HITCH CAPACITIES

Angle of Choke*	Sling Rated Load Factor
120 – 180	.75
90 – 119	.65
60 – 89	.55
30 – 59	.40

* in degrees

ANGLE POSITIONING

Vertical Dimension	Horizontal Dimension*
8	2
10	$2\frac{1}{2}$
12	3
16	4
20	5
24	6
28	7
32	8
36	9
40	10
44	11

* in ft

FLUID WEIGHTS/TEMPERATURE STANDARDS

Fluid	Weight*	Temperature**
Air	4.33×10^{-5}	20°C/68°F @ 29.92 in. Hg
Gasoline	.0237 – .0249	20°C/68°F
Kerosene	.0296	20°C/68°F
Mercury	.49116	0°C/32°F
Lubricating Oil	.0307 – .0318	15°C/59°F
Fuel Oil	.0336 – .0353	15°C/59°F
Water	.0361	4°C/39°F
Sea Water	.0370	15°C/59°F

* in lb/cu in.
** laboratory temperature conditions under which numerical values are defined

FORMULAS . . .

AREA
Circle (Radius)
$A = 3.1416 \times r^2$
where
A = area
3.1416 = constant (π)
r^2 = radius squared

Circle (Diameter)
$A = .7854 \times D^2$
where
A = area
$.7854$ = constant
D^2 = diameter squared

Square or Rectangle
$A = l \times w$
where
A = area
l = length
w = width

Triangle
$A = \frac{1}{2}bh$
where
A = area
$\frac{1}{2}$ = constant
b = base
h = height

VOLUME
Cylinder (Radius)
$V = \pi r^2 \times l$
where
V = volume
$\pi = 3.1416$
r^2 = radius squared
l = length

Cylinder (Diameter)
$V = .7854 \times D^2 \times h$
where
V = volume
$.7854$ = constant
D^2 = diameter squared
h = height

Rectangular Solid
$V = l \times w \times h$
where
V = volume
l = length
w = width
h = height

Sphere (Radius)
$V = \frac{4\pi r^3}{3}$
where
V = volume
4 = constant
$\pi = 3.1416$
r^3 = radius cubed
3 = constant

Sphere (Diameter)
$V = \frac{\pi D^3}{6}$
where
V = volume
$\pi = 3.1416$
D^3 = diameter cubed
6 = constant

Cone
$V = \frac{A_b \, a}{3}$
where
V = volume
A_b = area of base
a = altitude
3 = constant

PYTHAGOREAN THEOREM
$c = \sqrt{a^2 + b^2}$
where
c = length of hypotenuse
a^2 = length of one side squared
b^2 = length of other side squared

TEMPERATURE
Converting Fahrenheit to Celsius
$°C = \frac{°F - 32}{1.8}$
where
$°C$ = degrees Celsius
$°F$ = degrees Fahrenheit
32 = difference between bases
1.8 = ratio between bases

Converting Celsius to Fahrenheit
$°F = (1.8 \times °C) + 32$
where
$°F$ = degrees Fahrenheit
1.8 = ratio between bases
$°C$ = degrees Celsius
32 = difference between bases

Converting Fahrenheit to Rankine
$°R = 460 + °F$
where
$°R$ = degrees Rankine
460 = difference between bases
$°F$ = degrees Fahrenheit

Converting Celsius to Kelvin
$°K = 273 + °C$
where
$°K$ = degrees Kelvin
273 = difference between bases
$°C$ = degrees Celsius

STOCK MATERIAL WEIGHT
$W = l \times w/ft$
where
W = weight (in lb)
l = length (in ft)
w/ft = weight (in lb/ft)

LIFTING CAPACITY
$LC = vl \times l \times s$
where
LC = load capacity (in t)
vl = vertical load rate (from Vertical Sling Component Load Capacity 6 × 19 IPS-FC Classification table)
l = number of sling legs (not more than two)
s = loss factor (from Sling Angle Loss Factors table)

ROPE BENDING LOAD RATING
$R_{br} = R_{lr} \times R_{eff}$
where
R_{br} = rope bending load rating
R_{lr} = rope load rating
R_{eff} = relative efficiency rating

D/d Ratio
$R = \frac{D}{d}$
where
R = D/d ratio
D = diameter of rope curve (in in.)
d = diameter of rope (in in.)

ROPE STRENGTH
$R_s = t \times 5$
where
R_s = rope strength (in t)
t = weight (in t)
5 = constant (safety factor)

TONS
$T = \frac{w}{2000}$
where
T = weight (in t)
w = weight (in lb)
2000 = constant (to convert lb to t)

... FORMULAS ...

HOLDING LOADS

$$L = \frac{w}{p}$$

where
L = lead line force (in lb)
w = total load weight including weight of slings, containers, etc. (in lb)
p = number of parts

MOVING LOADS

$$L = f \times w$$

where
L = lead line force (in lb)
f = lead line factor (from Lead Line Factors table)
w = weight of load (in lb)

COMPRESSOR SIZE

$$HP = \frac{scfm}{4}$$

where
HP = horsepower
$scfm$ = standard cubic feet per minute
4 = constant

WORKING LOAD CAPACITY

$$L = \frac{c \times wl}{s}$$

where
L = working load capacity (in lb)
c = constant (.21 for sling angles less than 45°; .25 for sling angles greater than 45°)
wl = eyebolt working load limit (in lb)
s = sling angle loss factor (from Sling Angle Loss Factors table)

ABSOLUTE PRESSURE

$$psia = psig + 14.7$$

where
$psia$ = pounds per square inch absolute
$psig$ = pounds per square inch gauge
14.7 = constant (atmospheric pressure at standard conditions)

CYLINDER PRESSURE

$$P = \frac{F}{A}$$
$$F = P \times A$$
$$A = \frac{F}{P}$$

where
P = pressure
F = force
A = area

CYLINDER CAPACITY

$$C = \frac{V}{231}$$

where
C = capacity (in gal.)
V = volume (in cu in.)
231 = constant (cu in. of fluid per gal.)

PRESSURE OF FLUID IN CYLINDER

$$P = w \times h$$

where
P = pressure at base (in psi)
w = weight of fluid (in lb/cu in. from Fluid Weights/Temperature Standards table)
h = height (in in.)

FLUID VELOCITY

$$v = \frac{x_2 - x_1}{t_2 - t_1}$$

where
v = velocity (in ft/sec)
x_2 = final position (in ft)
x_1 = initial position (in ft)
t_2 = final time (in sec)
t_1 = initial time (in sec)

VELOCITY OF FLUID IN PIPE

$$v = \frac{l_2}{\frac{A \times l_1}{231}} \times \frac{60}{Q}$$

where
v = velocity (in ft/sec)
l_2 = length of pipe (in ft)
A = cross-sectional area of pipe (in sq in.)
l_1 = length of pipe (in in.)
231 = constant (cu in. of fluid per gallon)
Q = flow rate (in gpm)
60 = constant (sec in 1 min)

SPEED OF CYLINDER ROD

$$s = 231 \times \frac{Q}{.7854} \times D^2$$

where
s = speed of extension (in in./min)
231 = constant (cu in. of fluid per gallon)
Q = flow rate (in gpm)
.7854 = constant
D^2 = diameter of cylinder squared

FORCE TO OVERCOME RESISTANCE FORCE

$$F_1 = \frac{F_2 \times d_2}{d_1}$$

where
F_1 = effort force (in lb)
F_2 = resistance force (in lb)
d_1 = distance between effort force and fulcrum (in ft)
d_2 = distance between resistance force and fulcrum (in ft)

RESULTING FORCE WITHIN VESSEL

$$F_2 = F_1 \times \frac{A_2}{A_1}$$

where
F_2 = resulting force (in lb)
F_1 = input force (in lb)
A_2 = area of output pressure (in sq in.)
A_1 = area of input pressure (in sq in.)

EFFICIENCY

$$Eff_T = Eff_1 \times Eff_2 \times 100$$

where
Eff_T = total efficiency (in %)
Eff_1 = efficiency of component 1
Eff_2 = efficiency of component 2
100 = constant (to convert to percent)

POWER

$$P = \frac{F \times d}{t}$$

where
P = power (in lb-ft/time)
F = force (in lb)
d = distance (in ft or in.)
t = time (in sec, min, or hr)

HORSEPOWER
Mechanical

$$HP = \frac{F \times d}{550 \times t}$$

where
HP = horsepower
F = force (in lb)
d = distance (in ft)
550 = constant
t = time (in sec)

Hydraulic

$$HP = P \times Q \times .000583$$

where
HP = horsepower
P = pressure (in psi)
Q = flow rate (in gpm)
.000583 = constant

TORQUE

$$T = \frac{P \times d}{2\pi}$$

where
T = torque (in lb-in.)
P = pressure (in psi)
d = motor displacement (in cu in.)
π = constant (3.1416)

. . . FORMULAS

FINAL PRESSURE

$$P_2 = \frac{P_1 \times V_1}{V_2}$$

where
P_2 = final pressure (in psia)
P_1 = initial pressure (in psia)
V_1 = initial volume (in cubic units)
V_2 = final volume (in cubic units)

RATIO OF COMPRESSION

$$R_c = \frac{P_2}{P_1}$$

where
R_c = ratio of compression
P_2 = final pressure (in psia)
P_1 = initial pressure (in psia)

TORQUE

$T = F \times D$
where
T = torque (in lb-ft)
F = force (in lb)
D = distance (in in. or ft)

FINAL VOLUME

$$V_2 = \frac{P_1 \times V_1}{P_2}$$

where
V_2 = final volume (in cubic units)
P_1 = initial pressure (in psia)
V_1 = initial volume (in cubic units)
P_2 = final pressure (in psia)

PRESSURE LOSS

$$\Delta P = \frac{CQ^2}{1000} \times \frac{14.7}{14.7 + P}$$

where
ΔP = pressure drop (in psi)
C = constant (from Pressure Loss Constants table)
Q = air flow rate (in scfm)
14.7 = constant (atmospheric pressure)
1000 = constant
P = working pressure (in psi)

TORQUE OF ROTATING MACHINE

$$T = \frac{5252 \times HP}{rpm}$$

where
T = torque (in lb-ft)
5252 = constant (33,000 lb-ft ÷ $\pi \times 2$)
HP = horsepower
rpm = revolutions per minute

CHARLES' LAW

$$V_2 = \frac{V_1 \times T_2}{T_1}$$

where
V_2 = final volume (in cubic units)
V_1 = initial volume (in cubic units)
T_2 = final temperature (in °R)
T_1 = initial temperature (in °R)

BELT LENGTH

$$L = 2 \times C + 1.57 \times (D + d) + \frac{(D - d)^2}{4 \times C}$$

where
L = belt length (in in.)
2 = constant
C = distance between pulley centers (in in.)
1.57 = constant
D = large pulley diameter (in in.)
d = small pulley diameter (in in.)
4 = constant

HORSEPOWER REQUIRED TO OVERCOME LOAD

$$HP = \frac{T \times rpm}{5252}$$

where
HP = horsepower
T = torque (in lb-ft)
rpm = revolutions per minute
5252 = constant (33,000 lb-ft ÷ $\pi \times 2$)

GAY-LUSSAC'S LAW

$$P_2 = \frac{P_1 \times T_2}{T_1}$$

where
P_2 = final pressure (in psia)
P_1 = initial pressure (in psia)
T_2 = final temperature (in °R)
T_1 = initial temperature (in °R)

DEFLECTION HEIGHT

$h = L \times \frac{1}{64}''$
where
h = deflection height (in in.)
L = span length (in in.)
$\frac{1}{64}''$ = constant (.0156″)

SPEED OF DRIVEN GEAR

$$N_2 = \frac{T_1 \times N_1}{T_2}$$

where
N_2 = speed of driven gear (in rpm)
T_1 = number of teeth on drive gear
N_1 = speed of drive gear (in rpm)
T_2 = number of teeth on driven gear

COMBINED GAS LAW

$$P_2 = \frac{P_1 \times V_1}{T_1} \times \frac{T_2}{V_2}$$

where
P_2 = final pressure (in psia)
P_1 = initial pressure (in psia)
V_1 = initial volume (in cubic units)
T_1 = initial temperature (in °R)
T_2 = final temperature (in °R)
V_2 = final volume (in cubic units)

DRIVEN PULLEY SPEED

$$N_d = \frac{PD_m \times N_m}{PD_d}$$

where
N_d = driven pulley speed (in rpm)
PD_m = drive pulley diameter (in in.)
N_m = drive pulley speed (in rpm)
PD_d = driven pulley diameter (in in.)

COEFFICIENT OF FRICTION

$$f = \frac{F}{N}$$

where
f = coefficient of friction
F = force at which sliding occurs (in lb)
N = object weight (in lb)